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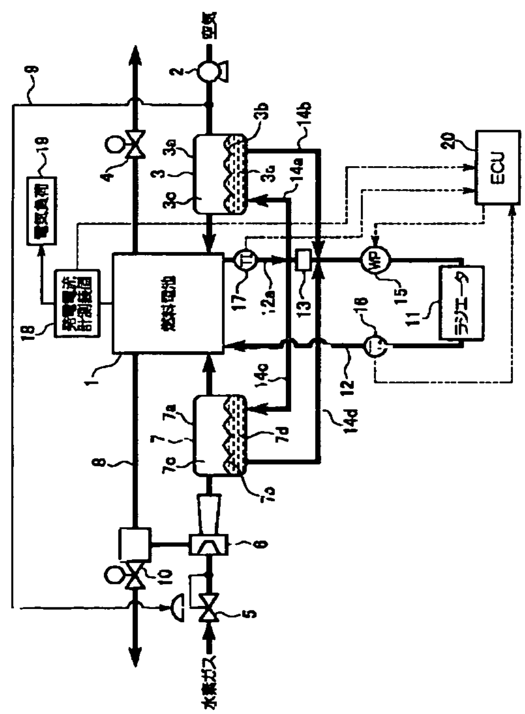
(54)【発明の名称】　燃料電池の冷却装置

(57)【要約】
【課題】　燃料電池の加湿性と水分排出性の向上を図る。
【解決手段】　水素ガスと空気を反応ガスとして発電を行う燃料電池１と、燃料電池１に供給される前記反応ガスを加湿する加湿器３，７と、ウォーターポンプ１５により冷却液を燃料電池１と放熱器１１との間で循環させ、燃料電池１内で冷却液を前記反応ガスと略同一方向に流して燃料電池１を冷却し、放熱器１１で冷却液から熱を外部に放熱する冷却液回路１２と、燃料電池１から排出された冷却液によって加湿器３，７を加熱する加熱手段（３ｄ，７ｄ）と、燃料電池１の冷却液出口温度と冷却液入口温度との間に所定の温度差が確保されるようにウォーターポンプ１５を制御する制御手段と、を備える。



【特許請求の範囲】

【請求項１】　燃料ガスと酸化剤ガスを反応ガスとして発電を行う燃料電池と、
循環ポンプにより冷却液を前記燃料電池と放熱器との間で循環させ、前記燃料電池内で冷却液を前記反応ガスと略同一方向に流して該燃料電池を冷却し、前記放熱器で冷却液から熱を外部に放熱する冷却手段と、
前記燃料電池の冷却液出口温度と冷却液入口温度との間に所定の温度差が確保されるように前記循環ポンプを制御する制御手段と、
を備えることを特徴とする燃料電池の冷却装置。

【請求項２】　燃料ガスと酸化剤ガスを反応ガスとして発電を行う燃料電池と、
前記燃料電池に供給される前記反応ガスを加湿する加湿器と、
循環ポンプにより冷却液を前記燃料電池と放熱器との間で循環させ、前記燃料電池内で冷却液を前記反応ガスと略同一方向に流して該燃料電池を冷却し、前記放熱器で冷却液から熱を外部に放熱する冷却手段と、
前記燃料電池から排出された前記冷却液によって前記加湿器を加熱する加熱手段と、
前記燃料電池の冷却液出口温度と冷却液入口温度との間に所定の温度差が確保されるように前記循環ポンプを制御する制御手段と、
を備えることを特徴とする燃料電池の冷却装置。

【請求項３】　前記燃料電池の出力に応じて前記温度差の目標値を変更することを特徴とする請求項１または請求項２に記載の燃料電池の冷却装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明は、燃料電池の冷却装置に関するものであり、特に、液冷式の冷却装置に関するものである。

【０００２】

【従来の技術】燃料電池自動車等に搭載される燃料電池には、例えば固体ポリマーイオン交換膜等からなる固体高分子電解質膜をアノードとカソードとで両側から挟み込んで形成されたセルを複数積層して構成されたスタックからなり、燃料ガスとして水素ガスが供給される水素ガス通路と、酸化剤ガスとして酸素を含む空気が供給される空気通路と、冷却液が供給される冷却液通路とを備えたものがある。以下、燃料ガスと酸化剤ガスを総称して反応ガスという。この燃料電池においては、アノードで触媒反応により発生した水素イオンが、固体高分子電解質膜を通過してカソードまで移動して、カソードで酸素と電気化学反応を起こして発電し、その際に水が生成される。

【０００３】ところで、燃料電池の発電には発熱を伴うが、燃料電池には作動温度範囲があるため燃料電池が上限温度以上に昇温しないように冷却する必要がある。そのため、燃料電池の前記冷却液通路に冷媒を流して熱を奪い燃料電池を冷却する冷却装置が設けられている。この燃料電池の冷却装置には、特開平１０－３４０７３４号公報に開示されているように、冷媒としての冷却液を循環ポンプにより燃料電池と放熱器（ラジエータ）との間で循環させるようにしたものがある。この冷却装置では、燃料電池から熱を奪って熱せられた冷却液が放熱器を流れる際に、冷却液の熱を外気に放熱して冷却液を冷却している。

【０００４】前記公報にも開示されているように、従来は燃料電池の内部温度が均一になるように冷却するのがシステム上、好ましいとされており、そのため、燃料電池の冷却液出口温度と冷却液入口温度との温度差を極力少なくなるように、冷却液の循環量を制御していた。

【０００５】

【発明が解決しようとする課題】しかしながら、このように燃料電池の冷却液出口温度と冷却液入口温度との温度差を少なくするということは、冷却液出口温度を下げる方向にすることであり、したがって、冷却液の循環量を増大することとなり、循環ポンプの消費電力が増大するので、エネルギーマネージメント上、不利であった。

【０００６】また、前述したように、燃料電池は発電に際して水が生成されるが、この水は未反応の反応ガス、すなわちオフガス中に水蒸気として気相で存在するものもあれば、液体となってオフガスから分離し液相で存在するものもある。水蒸気としてオフガス中に存在する水分はオフガスとともに燃料電池から排出されるので問題となることはないが、液状のものは場合によっては反応ガス路の一部を塞ぐ虞があり好ましい形態とは言えない。そこで、生成水等の水分の排出という観点からすると、燃料電池の内部温度が高い方が露点を上げることができ、水分を気相（水蒸気）でオフガス中に多く含ませることができ、オフガスとともに排出できる水分量を増大できるので好ましい。しかしながら、従来は、前述したように、燃料電池の冷却液出口温度と冷却液入口温度との温度差を少なくして冷却液出口温度を下げる方向に制御しているので、オフガス中の水分が液相になり易く、水分の排出性という点では改良の余地があった。

【０００７】一方で、固体高分子電解質膜を用いた燃料電池では、固体高分子電解質膜のイオン導電性を所定の状態に確保して良好な発電状態を維持するために、燃料電池に供給される反応ガス（水素ガスおよび空気）を加湿器で加湿しており、この加湿された反応ガスが燃料電池内で凝縮して固体高分子電解質膜に付着することにより、固体高分子電解質膜のイオン導電性を向上させている。このように燃料電池に対する加湿という観点からすると、燃料電池の内部温度は低い方が反応ガス中の水蒸気が凝結し易く好ましいこととなる。このような事情から、燃料電池に対する加湿性と前述した水分の排出性を両立させて燃料電池の内部温度を制御するのは、極めて

困難であった。

【0008】そこで、この発明は、反応ガスと冷却液の流れ方向が略同一方向にされた構造の燃料電池における内部温度分布に積極的に温度差を確保することにより、燃料電池における水分の排出性に優れた燃料電池の冷却装置を提供するものである。また、この発明は、反応ガスと冷却液の流れ方向が略同一方向にされた構造の燃料電池における内部温度分布に積極的に温度差を確保することにより、燃料電池における水分の排水性の向上と固体高分子電解質膜に対する加湿性の向上の両立を図ることができる燃料電池の冷却装置を提供するものである。

【0009】

【課題を解決するための手段】上記課題を解決するために、請求項１に記載した発明は、燃料ガス（例えば、後述する各実施の形態における水素ガス）と酸化剤ガス（例えば、後述する各実施の形態における空気）を反応ガスとして発電を行う燃料電池（例えば、後述する各実施の形態における燃料電池１）と、循環ポンプ（例えば、後述する各実施の形態におけるウォーターポンプ１５）により冷却液を前記燃料電池と放熱器（例えば、後述する各実施の形態におけるラジエータ１１）との間で循環させ、前記燃料電池内で冷却液を前記反応ガスと略同一方向に流して該燃料電池を冷却し、前記放熱器で冷却液から熱を外部に放熱する冷却手段（例えば、後述する各実施の形態における冷却液回路１２）と、前記燃料電池の冷却液出口温度と冷却液入口温度との間に所定の温度差が確保されるように前記循環ポンプを制御する制御手段（例えば、後述する第１の実施の形態におけるステップＳ１０３，１０５，１０６、および、第２の実施の形態におけるステップＳ２０８，２０９，２１０、および、第４の実施の形態におけるステップＳ３０５，３０７，３０８）と、を備えることを特徴とする燃料電池の冷却装置である。

【0010】このように構成することにより、前記制御手段による循環ポンプの制御で、燃料電池の冷却液出口温度と冷却液入口温度との間に所定の温度差が確保されるので、冷却液出口温度が高めに制御されることとなり、さらに、燃料電池内では反応ガスと冷却液が略同一方向に流れることから、未反応の反応ガス（以下、オフガスという）の燃料電池出口温度を高くすることができ、その結果、オフガスの露点を高くすることができ、オフガス中に気相（水蒸気）で存在する水分量を増大させることが可能になる。また、冷却液出口温度を高めに制御するようになることから、冷却液の循環量を減少させることができる。

【0011】請求項２に記載した発明は、燃料ガス（例えば、後述する各実施の形態における水素ガス）と酸化剤ガス（例えば、後述する各実施の形態における空気）を反応ガスとして発電を行う燃料電池（例えば、後述する各実施の形態における燃料電池１）と、前記燃料電池に供給される前記反応ガスを加湿する加湿器（例えば、後述する各実施の形態におけるカソード加湿器３およびアノード加湿器７）と、循環ポンプ（例えば、後述する各実施の形態におけるウォーターポンプ１５）により冷却液を前記燃料電池と放熱器（例えば、後述する各実施の形態におけるラジエータ１１）との間で循環させ、前記燃料電池内で冷却液を前記反応ガスと略同一方向に流して該燃料電池を冷却し、前記放熱器で冷却液から熱を外部に放熱する冷却手段（例えば、後述する各実施の形態における冷却液回路１２）と、前記燃料電池から排出された前記冷却液によって前記加湿器を加熱する加熱手段（例えば、後述する第１，第２の実施の形態における第２室３ｄ，７ｄ、および、第３の実施の形態におけるウォータージャケット３ｅ，７ｅ）と、前記燃料電池の冷却液出口温度と冷却液入口温度との間に所定の温度差が確保されるように前記循環ポンプを制御する制御手段（例えば、後述する第１の実施の形態におけるステップＳ１０３，１０５，１０６、および、第２の実施の形態におけるステップＳ２０８，２０９，２１０、および、第４の実施の形態におけるステップＳ３０５，３０７，３０８）と、を備えることを特徴とする燃料電池の冷却装置である。

【0012】このように構成することにより、前記制御手段による循環ポンプの制御で、燃料電池の冷却液出口温度と冷却液入口温度との間に所定の温度差が確保されるので、冷却液出口温度が高めに制御されることとなり、さらに、燃料電池内では反応ガスと冷却液が略同一方向に流れることから、オフガスの燃料電池出口温度を高くすることができ、その結果、オフガスの露点を高くすることができ、オフガス中に気相（水蒸気）で存在する水分量を増大させることが可能になる。

【0013】また、加熱手段が冷却液で加湿器を加熱しているので、燃料電池に供給される反応ガスの温度が高まり、加湿器における反応ガスに対する加湿が促進される。しかも、燃料電池の冷却液出口温度と冷却液入口温度との間に所定の温度差が確保され、燃料電池内では反応ガスと冷却液が略同一方向に流れることから、前記加湿器で加熱・加湿された反応ガスは燃料電池に供給された直後に冷却液によって冷却され、反応ガス中の蒸気が凝結して液状になり易くなり、燃料電池を加湿し易くなる。さらに、冷却液出口温度を高めに制御するようになることから、冷却液の循環量を減少させることができる。

【0014】請求項３に記載した発明は、請求項１または請求項２に記載の発明において、前記燃料電池の出力に応じて前記温度差の目標値を変更することを特徴とする。このように構成することにより、燃料電池が低出力のときには、冷却液出口温度と冷却液入口温度との温度差を小さく設定して、燃料電池を流れる冷却液流量を増加させることが可能になり、一方、燃料電池が高出力の

ときには、冷却液出口温度と冷却液入口温度との温度差を大きく設定して、燃料電池を流れる冷却液流量を減少させることが可能になる。

【0015】

【発明の実施の形態】以下、この発明に係る燃料電池の冷却装置（単に冷却装置ということもある）の実施の形態を図１から図１０の図面を参照して説明する。なお、以下に説明する実施の形態は、燃料電池自動車に搭載される燃料電池の冷却装置に適用した態様である。

【００１６】〔第１の実施の形態〕この発明に係る燃料電池の冷却装置の第１の実施の形態を図１から図５の図面を参照して説明する。図１は冷却装置の概略構成図である。初めに、冷却対象となる燃料電池１について説明する。燃料電池１は固体高分子電解質膜型の燃料電池であり、図２に示すように、例えば固体ポリマーイオン交換膜等からなる固体高分子電解質膜５１をアノード５２とカソード５３とで両側から挟み込み、さらにその外側を一対のセパレータ５４，５４で挟持して形成されたセル５５を複数積層して構成されたスタックからなり、燃料ガスとして水素ガスが供給される水素ガス通路５６と、酸化剤ガスとして酸素を含む空気が供給される空気通路５７と、冷却液が供給される冷却液通路５８とを備えている。そして、アノード５２で触媒反応により発生した水素イオンが、固体高分子電解質膜５１を通過してカソード５３まで移動して、カソード５３で酸素と電気化学反応を起こして発電し、その際に水が生成される。また、この発電に伴う発熱により燃料電池１が上限温度を越えないように、前記冷却液通路５８を流れる冷却液で熱を奪い冷却するようになっている。

【００１７】また、この燃料電池１においては、水素ガス通路５６と空気通路５７と冷却液通路５８が互いに平行して設けられている。図３は、これら通路５６，５７，５８を模式的に示した斜視図であり、これら通路５６，５７，５８はいずれも、セル５５の左上部の入口から右下部の出口まで同一形態に蛇行して設けられている。したがって、この実施の形態では、水素ガス通路５６と空気通路５７と冷却液通路５８はその全長に亘ってそれぞれの流体の流れ方向を同一方向にされている。

【００１８】次に、冷却装置を各流体の流れに沿って説明する。外気はエアコンプレッサ２によって加圧され、カソード加湿器３で加湿されて燃料電池１の空気通路５７に供給され、この空気中の酸素が酸化剤として発電に供された後、燃料電池１から空気オフガスとして排出され、圧力制御弁４を介して大気に放出される。エアコンプレッサ２は、燃料電池１に要求されている出力に応じた質量の空気が燃料電池１に供給されるように回転数制御され、また、圧力制御弁４は、燃料電池１への空気の供給圧が燃料電池１の運転状態に応じた圧力値となるように開度制御される。

【００１９】カソード加湿器３は、ケーシング３ａの内部が水蒸気透過膜３ｂによって上下二室に離隔されており、上側の第１室３ｃにエアコンプレッサ２および燃料電池１の空気通路５７入口が接続され、下側の第２室３ｄには後述するように燃料電池１から排出された冷却液が循環するようになっている。水蒸気透過膜３ｂは、該水蒸気透過膜３ｂを境にして水蒸気圧の高い方から水蒸気圧の低い方へ水蒸気だけを透過させる機能を有するものである。

【００２０】一方、図示しない高圧水素タンクから放出された水素ガスは燃料供給制御弁５により減圧された後、エゼクタ６を通り、アノード加湿器７で加湿されて燃料電池１の水素ガス通路５６に供給される。この水素ガスは発電に供された後、未反応の水素ガスは燃料電池１から水素オフガスとして排出され、水素オフガス回収路８を通ってエゼクタ６に吸引され、前記高圧水素タンクから供給される水素ガスと合流し再び燃料電池１に供給されるようになっている。

【００２１】燃料供給制御弁５は、例えば空気式の比例圧力制御弁からなり、エアコンプレッサ２から供給される空気の圧力を信号圧として空気信号導入路９を介して入力され、燃料供給制御弁５出口の水素ガスの圧力が前記信号圧に応じた所定圧力範囲となるように減圧制御する。水素オフガス回収路８はパージ弁１０を備えており、パージ弁１０は所定条件が満たされたときに開弁制御されて、燃料電池１の水素ガス通路５６に水が溜まらないように外部へ排水する。

【００２２】アノード加湿器７は、カソード加湿器３と同様の構造をなしており、ケーシング７ａの内部が水蒸気透過膜７ｂによって上下二室に離隔されており、上側の第１室７ｃにエゼクタ６およびおよび燃料電池１の水素ガス通路５６入口が接続され、下側の第２室７ｄには後述するように燃料電池１から排出された冷却液が循環するようになっている。ここで、前記カソード加湿器３は水蒸気透過膜３ｂを透過した冷却液の蒸気により空気を加湿し、加湿した空気を燃料電池１に供給し、また、アノード加湿器７は水蒸気透過膜７ｂを透過した冷却液の蒸気により水素ガスを加湿し、加湿した水素ガスを燃料電池１に供給する。これにより、燃料電池１の固体高分子電解質膜のイオン導電性が所定の状態に確保される。

【００２３】また、燃料電池１を冷却するための冷却液は、循環ポンプであるウォーターポンプ（ＷＰ）１５によって昇圧されてラジエータ（放熱器）１１に供給され、ラジエータ１１において外部に放熱することにより冷却液は冷却され、その後、燃料電池１に供給され、燃料電池１内の冷却液通路５８を通る際に燃料電池１から熱を奪って燃料電池１を冷却し、これにより熱せられた冷却液はウォーターポンプ１５を介して再びラジエータ１１に戻り冷却されるようになっている。すなわち、冷却液は、燃料電池１とウォーターポンプ１５とラジエー

タ１１とを閉回路に接続する冷却液回路（冷却手段）１２を循環するようになっている。

【００２４】冷却液回路１２において燃料電池１からウォーターポンプ１５に向かう冷却液主流路（すなわち、燃料電池１の下流であってウォーターポンプ１５の上流に位置する冷却液流路）１２ａには制限オリフィス１３が設けられている。冷却液主流路１２ａにおいてオリフィス１３の上流（すなわち、燃料電池１寄り）および下流（すなわち、ラジエータ１１寄り）はそれぞれ冷却液副流路１４ａ，１４ｂによってカソード加湿器３の第２室３ｄに接続されるとともに、冷却液副流路１４ｃ，１４ｄによってアノード加湿器７の第２室７ｄに接続されている。これにより、冷却液主流路１２ａを流れる冷却液の一部は冷却液副流路１４ａ，１４ｃを通ってカソード加湿器３の第２室３ｄおよびアノード加湿器７の第２室７ｄに導入され、冷却液副流路１４ｂ，１４ｄを通って冷却液主流路１２ａに戻るようになっている。なお、この第１の実施の形態においてカソード加湿器３の第２室３ｄとアノード加湿器７の第２室７ｄは加熱手段を構成する。

【００２５】また、冷却液回路１２において燃料電池１の入口側には、燃料電池１に供給される冷却液の温度（以下、冷却液入口温度という）を検出する入口温度センサ（ＴＩ）１６が設けられており、冷却液回路１２において燃料電池１の出口側には、燃料電池１から排出される冷却液の温度（以下、冷却液出口温度という）を検出する出口温度センサ（ＴＩ）１７が設けられている。電子制御ユニット（以下、ＥＣＵと略す）２０は、これら温度センサ１６，１７の出力信号に基づいてウォーターポンプ１５の出力を制御する。

【００２６】燃料電池１から取り出される発電電流は、発電電流を計測する発電電流計測装置１８を介して、走行用モータやエアコンプレッサ２を駆動するモータ等の電気負荷１９に接続されている。

【００２７】次に、この第１の実施の形態における燃料電池の冷却装置の作用を説明する。この実施の形態における冷却装置では、燃料電池１の冷却液出口温度が冷却液入口温度よりも所定温度だけ高くなるように、換言すれば、冷却液出口温度と冷却液入口温度との間に所定温度差が確保されるように、ウォーターポンプ１５の出力を制御する。図4は、冷却液入口温度の上限温度を８０°Ｃとし、冷却液出口温度と冷却液入口温度との目標温度差を１０ｄｅｇｒｅｅ（以下、「ｄｅｇ」と略す）とした場合における冷却液の温度制御フローチャートを示しており、これに従って温度制御処理を説明する。

【００２８】まず、入口温度センサ１６と出口温度センサ１７で検出した冷却液入口温度Ｔ１と冷却液出口温度Ｔ２を読み込み（ステップＳ１０１）、冷却液入口温度Ｔ１が上限温度（８０°Ｃ）よりも低いか否かを判定する（ステップＳ１０２）。判定結果が「ＮＯ」（冷却液入口温度Ｔ１が８０°Ｃ以上）である場合は、ウォーターポンプ１５の出力を増大して（ステップＳ１０３）、本ルーチンの実行を一旦終了する。これにより、冷却液の循環量が増大し、冷却液入口温度Ｔ１は下げる方向に制御されることとなる。

【００２９】ステップＳ１０２における判定結果が「ＹＥＳ」（冷却液入口温度Ｔ１が８０°Ｃ未満）である場合は、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１の温度差ΔＴを算出し（ステップＳ１０４）、算出された温度差ΔＴが目標温度差（１０ｄｅｇ）よりも小さいか否か判定する（ステップＳ１０５）。判定結果が「ＮＯ」（温度差ΔＴが１０ｄｅｇ以上）である場合は、ウォーターポンプ１５の出力を増大して（ステップＳ１０３）、本ルーチンの実行を一旦終了する。これにより、冷却液の循環量が増大し、温度差ΔＴは小さくなる方向に制御されることとなる。

【００３０】ステップＳ１０５における判定結果が「ＹＥＳ」（温度差ΔＴが１０ｄｅｇ未満）である場合は、ウォーターポンプ１５の出力を低減して（ステップＳ１０６）、本ルーチンの実行を一旦終了する。これにより、冷却液の循環量が減少し、温度差ΔＴは大きくなる方向に制御されることとなる。以上の温度制御処理を実行することにより、冷却液入口温度Ｔ１は８０°Ｃ以下に収束するようになり、且つ、温度差ΔＴは目標温度差（１０ｄｅｇ）に収束するようになる。また、このように冷却液温度を制御すると、冷却液入口温度Ｔ１が上限温度を超えない範囲で冷却液出口温度Ｔ２が高めに制御されることとなる。

【００３１】そして、この冷却装置では、燃料電池１から熱を奪って温度上昇した冷却液がカソード加湿器３の第２室３ｄに供給されるので、カソード加湿器３の第１室３ｃ内の空気が加熱され、該空気の相対湿度が下がり、該空気の露点を上げることができる。その結果、第２室３ｄ内の冷却液の一部が水蒸気となって水蒸気透過膜３ｂを透過し、第１室３ｃ内の空気に対する加湿を促進する。

【００３２】しかも、燃料電池１の冷却液出口温度Ｔ２と冷却液入口温度Ｔ１との間に所定の温度差（目標温度差１０ｄｅｇ）が確保されるように温度制御されており、燃料電池１における冷却液入口位置と空気入口位置が同一でその流れ方向が同一方向であるので、カソード加湿器３で加熱・加湿された空気は燃料電池１に供給された直後に冷却液によって冷却されることとなり、該空気中の蒸気が凝結して液状になり易くなる。その結果、燃料電池１の固体高分子電解質膜５１を加湿し易くなる。

【００３３】アノード加湿器７についても同様であり、燃料電池１から排出された冷却液がアノード加湿器７の第２室７ｄに供給されることにより、第１室７ｃ内の空気に対する加湿が促進される。そして、アノード加湿器

７で加熱・加湿された水素ガスは燃料電池１に供給された直後に冷却液によって冷却されるので、水素ガス中の蒸気が凝結して液状になり易くなり、固体高分子電解質膜５１を加湿し易くなる。したがって、固体高分子電解質膜５１のイオン導電性が所定の状態に確実に確保されるようになり、燃料電池１に対する加湿性が向上する。

【００３４】また、冷却液入口温度Ｔ１が上限温度を超えない範囲で冷却液出口温度Ｔ２が高めに制御され、さらに、燃料電池１内では水素ガス及び空気と冷却液が同一方向に流れながら熱交換が行われるので、水素オフガスおよび空気オフガスの燃料電池１出口での温度を高くすることができる。その結果、これらオフガスの露点を高くすることができ、オフガス中に気相（水蒸気）で存在する水分量を増大させることができる。したがって、燃料電池１における水分の排出性が向上し、水素ガス通路５６および空気通路５７において水閉塞が起こり難くなる。

【００３５】また、冷却液出口温度Ｔ２を高めに制御していることから、冷却液の循環量を減少させることができ、ウォーターポンプ１５の消費電力を減少させることができる。

【００３６】なお、燃料電池１における水素ガス通路５６、空気通路５７、冷却液通路５８の配置は図３に示す形態に限るものではない。例えば、図５に示すように、水素ガス通路５６はセル５５の左上部の入口から右下部の出口に向かって蛇行して設けられ、空気通路５７はセル５５の右上部の入口から左下部の出口に向かって蛇行して設けられ、冷却液通路５８はセル５５の上部から下部に向かって直線的に設けられていてもよい。この場合、水素ガスと空気は蛇行しながらもセル５５の上位から下位に向かって流れているので、その流れ方向は、上から下に向かって流れる冷却液の流れ方向と略同一方向であると言うことができる。

【００３７】〔第２の実施の形態〕次に、この発明に係る燃料電池の冷却装置の第２の実施の形態を図６および図７の図面を参照して説明する。第２の実施の形態における冷却装置が第１の実施の形態のものと相違する点は以下の通りである。冷却液回路１２には、ラジエータ１１の下流であって入口温度センサ１６の上流に、流量制御弁Ｖ１が設けられている。また、冷却液回路１２には、ウォーターポンプ１５の下流と入口温度センサ１６の上流とを接続しラジエータ１１および流量制御弁Ｖ１を迂回するバイパス通路２１が設けられており、バイパス通路２１には流量制御弁Ｖ２が設けられている。その他の構成については第１の実施の形態のものと同じであるので、同一態様部分に同一符号を付して説明を省略する。

【００３８】この第２の実施の形態の冷却装置では、ＥＣＵ２０は、入口温度センサ１６と出口温度センサ１７の出力信号に基づいて、ウォーターポンプ１５の出力と、流量制御弁Ｖ１，Ｖ２の開度を制御する。図７は、冷却液入口温度の上限温度を８０°Ｃとし、冷却液入口温度の目標温度（以下、目標冷却液入口温度という）を６５°Ｃとし、冷却液出口温度と冷却液入口温度との目標温度差を１０ｄｅｇとした場合における冷却液の温度制御フローチャートを示している。

【００３９】この場合の温度制御処理では、まず、入口温度センサ１６と出口温度センサ１７で検出した冷却液入口温度Ｔ１と冷却液出口温度Ｔ２を読み込み（ステップＳ２０１）、冷却液入口温度Ｔ１が上限温度（８０°Ｃ）よりも低いか否かを判定する（ステップＳ２０２）。判定結果が「ＮＯ」（冷却液入口温度Ｔ１が８０°Ｃ以上）である場合は、ウォーターポンプ１５の出力を増大し、流量制御弁Ｖ１の開度を増大し、流量制御弁Ｖ２の開度を減少させて（ステップＳ２０３）、本ルーチンの実行を一旦終了する。このようにすると、燃料電池１を循環する冷却液の流量が増大し、ラジエータ１１を通過する冷却液の流量が増大し、バイパス通路２１を通過する冷却液の流量が減少するので、冷却液入口温度Ｔ１は急速に下がる方向に制御されることとなる。

【００４０】ステップＳ２０２における判定結果が「ＹＥＳ」（冷却液入口温度Ｔ１が８０°Ｃ未満）である場合は、冷却液入口温度Ｔ１が目標冷却液入口温度（６５°Ｃ）よりも大きいか否かを判定する（ステップＳ２０４）。判定結果が「ＮＯ」（冷却液入口温度Ｔ１が６５°Ｃ以下）である場合は、流量制御弁Ｖ１の開度を減少し、流量制御弁Ｖ２の開度を増大させる（ステップＳ２０５）。このようにすると、ラジエータ１１を通過する冷却液の流量が減少し、バイパス通路２１を通過する冷却液の流量が増大するので、冷却液入口温度Ｔ１は上がる方向に制御されることとなる。

【００４１】ステップＳ２０４における判定結果が「ＹＥＳ」（冷却液入口温度Ｔ１が６５°Ｃより高い）である場合は、流量制御弁Ｖ１の開度を増大し、流量制御弁Ｖ２の開度を減少させる（ステップＳ２０６）。このようにすると、ラジエータ１１を通過する冷却液の流量が増大し、バイパス通路２１を通過する冷却液の流量が減少するので、冷却液入口温度Ｔ１は下がる方向に制御されることとなる。すなわち、ステップＳ２０５あるいはステップＳ２０６の処理を実行することにより、冷却液入口温度Ｔ１は目標冷却液入口温度（６５°Ｃ）に収束すべく制御されることとなる。

【００４２】ステップＳ２０５あるいはステップＳ２０６の後、ステップＳ２０７に進み、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１の温度差ΔＴを算出し、算出された温度差ΔＴが目標温度差（１０ｄｅｇ）よりも小さいか否か判定する（ステップＳ２０８）。判定結果が「ＮＯ」（温度差ΔＴが１０ｄｅｇ以上）である場合は、ウォーターポンプ１５の出力を増大して（ステップＳ２０９）、本ルーチンの実行を一旦終了する。これにより、

冷却液の循環量が増大し、温度差ΔTは小さくなる方向に制御されることとなる。
【0043】ステップS208における判定結果が「YES」（温度差ΔTが10deg未満）である場合は、ウォーターポンプ15の出力を低減して（ステップS210）、本ルーチンの実行を一旦終了する。これにより、冷却液の循環量が減少し、温度差ΔTは大きくなる方向に制御されることとなる。以上の温度制御処理を実行することにより、冷却液入口温度T1は65°Cに収束するようになり、且つ、温度差ΔTは目標温度差（10deg）に収束するようになる。この第2の実施の形態の冷却装置においても、第1の実施の形態と同様の作用があり、したがって、燃料電池1に対する加湿性の向上、燃料電池1における水分排出性の向上、ウォーターポンプ15の消費電力の減少を実現することができる。
【0044】〔第3の実施の形態〕次に、この発明に係る燃料電池の冷却装置の第3の実施の形態を図8の図面を参照して説明する。なお、以下の説明は、第3の実施の形態と第1の実施の形態との相違点だけに留め、第1の実施の形態のものと同一構成部分については図中、同一態様部分に同一符号を付して説明を省略する。第3の実施の形態では、カソード加湿器3が空気供給経路と空気オフガス経路に跨って設けられており、アノード加湿器7が水素ガス供給経路と水素オフガス経路に跨って設けられている。詳述すると、カソード加湿器3は、空気供給経路においてはエアコンプレッサ2の下流であり、空気オフガス経路においては圧力制御弁4の上流に設けられている。アノード加湿器7は、水素ガス供給経路においてはエゼクタ6の下流であり、水素オフガス経路においてはパージ弁10の上流に設けられている。
【0045】カソード加湿器3は、ケーシング3aの内部が水蒸気透過膜3bによって上下二室に離隔されている点において第1の実施の形態のカソード加湿器3と同一構成であるが、第3の実施の形態では、下側の第2室3dにエアコンプレッサ2および燃料電池1の空気通路57入口が接続され、上側の第1室3cに燃料電池1の空気通路57出口および圧力制御弁4が接続されている。したがって、エアコンプレッサ2から供給された空気はカソード加湿器3の第2室3dを通って燃料電池1の空気通路57に供給され、燃料電池1から排出された空気オフガスはカソード加湿器3の第1室3cを通って圧力制御弁4から大気に排出されることとなる。また、第3の実施の形態のカソード加湿器3は、ケーシング3aの外側にウォータージャケット3eを形成するアウターケーシング3fを備えている。そして、このウォータージャケット3eに冷却液副流路14a，14bが接続されており、燃料電池1から排出された冷却液がウォータージャケット3eを循環可能になっている。
【0046】したがって、この第3に実施の形態のカソード加湿器3においては、燃料電池1から熱を奪って温度上昇した冷却液がウォータージャケット3eを循環することにより、第2室3d内の空気と第1室3c内の空気オフガスが加熱される。第2室3d内の空気が加熱されると、該空気の相対湿度が下がり、該空気の露点を上げることができ、第2室3d内の空気は加湿され易い状態となる。一方、第1室3c内の空気オフガスが加熱されると、空気オフガスに含まれている液状の水の蒸発を促進することができ、この蒸発によって発生した蒸気と空気オフガスに元々気相として含まれていた水蒸気が水蒸気透過膜3bを透過して第2室3d内に移動し、第2室3d内の空気を加湿する。すなわち、ウォータージャケット3eに温度の高い冷却液を循環することにより、第2室3d内の空気に対する加湿を促進することができる。
【0047】また、アノード加湿器7もカソード加湿器3と同様に構成されており、下側の第2室7dにエゼクタ6および燃料電池1の水素ガス通路56入口が接続され、上側の第1室7cに燃料電池1の水素ガス通路56出口および水素オフガス回収路8が接続されている。したがって、エゼクタ6から供給された水素ガスはアノード加湿器7の第2室7dを通って燃料電池1の水素オフガス通路56に供給され、燃料電池1から排出された水素オフガスはアノード加湿器7の第1室7cを通って水素オフガス回収路8に排出されることとなる。そして、ケーシング7aとアウターケーシング7fの間に設けられたウォータージャケット7eに冷却液副流路14c，14dが接続され、燃料電池1から排出された冷却液がウォータージャケット7eを循環可能になっている。
【0048】したがって、この第3に実施の形態のアノード加湿器7においては、燃料電池1から熱を奪って温度上昇した冷却液がウォータージャケット7eを循環することにより、第2室7d内の水素ガスと第1室7c内の水素オフガスが加熱される。第2室7d内の水素ガスが加熱されると、該水素ガスの相対湿度が下がり、該水素ガスの露点を上げることができ、第2室7d内の水素ガスは加湿され易い状態となる。一方、第1室7c内の水素オフガスが加熱されると、水素オフガスに含まれている液状の水の蒸発を促進することができ、この蒸発によって発生した蒸気と水素オフガスに元々気相として含まれていた水蒸気が水蒸気透過膜7bを透過して第2室7d内に移動し、第2室7d内の空気を加湿する。すなわち、ウォータージャケット7eに温度の高い冷却液を循環することにより、第2室7d内の水素ガスに対する加湿を促進することができる。なお、この第3の実施の形態においてカソード加湿器3のウォータージャケット3eとアノード加湿器7のウォータージャケット7eは加熱手段を構成する。
【0049】そして、この第3の実施の形態の冷却装置においても、第1の実施の形態の場合と同様に、燃料電池1の冷却液出口温度T2と冷却液入口温度T1との間

に所定の温度差（例えば、目標温度差１０ｄｅｇ）が確保されるように温度制御する。このようにすると第３の実施の形態の冷却装置によっても第１の実施の形態の冷却装置と同様の作用・効果を得ることができる。

【００５０】すなわち、燃料電池１の冷却液出口温度Ｔ２と冷却液入口温度Ｔ１との間に所定の温度差（目標温度差１０ｄｅｇ）が確保されるように温度制御されており、燃料電池１における冷却液入口位置と反応ガス入口位置が同一でその流れ方向が同一方向であるので、カソード加湿器３およびアノード加湿器７で加熱・加湿された反応ガスは燃料電池１に供給された直後に冷却液によって冷却されることとなり、該反応ガス中の蒸気が凝結して液状になり易くなる。その結果、燃料電池１の固体高分子電解質膜５１を加湿し易くなる。

【００５１】また、冷却液入口温度Ｔ１が上限温度を超えない範囲で冷却液出口温度Ｔ２が高めに制御され、さらに、燃料電池１内では水素ガス及び空気と冷却液が同一方向に流れながら熱交換が行われるので、水素オフガスおよび空気オフガスの燃料電池１出口での温度を高くすることができる。その結果、これらオフガスの露点を高くすることができ、オフガス中に気相（水蒸気）で存在する水分量を増大させることができる。したがって、燃料電池１における水分の排出性が向上し、水素ガス通路５６および空気通路５７において水閉塞が起こり難くなる。

【００５２】さらに、冷却液出口温度Ｔ２を高めに制御していることから、冷却液の循環量を減少させることができ、ウォーターポンプ１５の消費電力を減少させることができる。

【００５３】〔第４の実施の形態〕次に、この発明に係る燃料電池の冷却装置の第４の実施の形態を図９および図１０の図面を参照して説明する。前述した各実施の形態の冷却装置では、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１の温度差ΔＴの目標温度差（目標値）を一定（例えば、１０ｄｅｇ）にしているが、第４の実施の形態の冷却装置では、温度差ΔＴの目標温度差を可変にし、燃料電池１の出力（発電量）に応じて目標温度差を変化させるようにする。

【００５４】初めに、目標温度差を可変にする理由について説明する。燃料電池１の発熱量は燃料電池１の出力（発電電流）に応じて異なり、低出力（発電電流が小さい）領域では発熱量が小さく、高出力（発電電流が大きい）領域では発熱量が大きい。そのため、低出力領域では燃料電池１を冷却する冷却液の流量は少なくて済み、高出力領域では冷却液の流量が多く必要になる。

【００５５】ここで、低出力領域において冷却液の流量が少なくなると、燃料電池１における冷却液流路構造のばらつきや燃料電池１におけるセル位置の関係により、全セルに対して均一な冷却状態の確保が困難になり、セル間あるいはセル位置に対する温度ばらつきが発生し、部分的に高温領域（ヒートポイント）が生じ、固体高分子電解質膜５１などを痛める虞がある。したがって、燃料電池１の低出力領域においては、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１との温度差ΔＴを小さく設定して冷却液流量を増加させた方が、ヒートポイントを生じにくくなり、燃料電池１にとって好ましい。

【００５６】一方、高出力領域において冷却液の流量が多くなると、燃料電池１における冷却液流路構造のばらつきがあっても、各セルでほぼ均一な冷却状態が確保できるのでヒートポイントが発生することはない。しかしながら、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１との温度差ΔＴを燃料電池１の低・中出力領域のときと同じ温度差ΔＴに確保しようとすると、冷却液流量が大きくなるためウォーターポンプ１５の出力が大きくなって、ウォーターポンプ１５の消費電力が大きくなってしまう。ここで、ウォーターポンプ１５の電力は燃料電池１の発電によって賄われることから、結果的に発電効率が低下することとなる。したがって、燃料電池１の高出力領域においては、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１との温度差ΔＴを大きく設定して冷却液流量を減少させた方が、ウォーターポンプ１５の消費電力を減少させることができ、エネルギーマネージメント上、好ましい。そこで、この第４の実施の形態の冷却装置では、燃料電池１の出力に応じて目標温度差を変化させて、冷却液の温度制御を実行することにした。

【００５７】次に、第４の実施の形態の冷却装置について具体的に説明する。以下の説明では、冷却装置の構成については図１に示すものと同じとしてその説明は省略する。図９は、冷却液入口温度の上限温度を８０°Ｃとし、冷却液出口温度と冷却液入口温度との目標温度差を燃料電池１の出力に応じた目標温度差ΔＴαにする場合における冷却液の温度制御フローチャートを示しており、これに従って温度制御処理を説明する。

【００５８】まず、燃料電池１の出力（発電量）を知るために、発電電流計測装置１８で検出した燃料電池１の発電電流を読み込む（ステップＳ３０１）。次に、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１との目標温度差ΔＴαを燃料電池１の発電電流に応じて算出する（ステップＳ３０２）。目標温度差ΔＴαは、例えば図１０に示すような目標温度差マップを参照して算出してもよいし、あるいは、発電電流と目標温度差ΔＴαとの関係式に基づいて計算により算出してもよい。

【００５９】ここで、図１０の目標温度差マップについて説明すると、発電電流がＩＡ１以下では目標温度差ΔＴαはΔＴ１で一定であり、発電電流がＩＡ１を越えてＩＡ２以下では目標温度差ΔＴαはΔＴ１からΔＴ２まで漸次大きくなり、発電電流がＩＡ２を越えてＩＡ３未満では目標温度差ΔＴαはΔＴ２からΔＴ３まで漸次大きくなり、発電電流がＩＡ３以上では目標温度差ΔＴαはΔＴ３で一定になっている。なお、発電電流がＩＡ１

～ＩＡ２における目標温度差ΔＴαの上昇率は、発電電流がＩＡ２～ＩＡ３における目標温度差ΔＴαの上昇率よりも大きく設定されている。

【００６０】このようにして燃料電池１の発電電流に応じた目標温度差ΔＴαを算出した後、入口温度センサ１６と出口温度センサ１７で検出した冷却液入口温度Ｔ１と冷却液出口温度Ｔ２を読み込み（ステップＳ３０３）、冷却液入口温度Ｔ１が上限温度（８０°Ｃ）よりも低いか否かを判定する（ステップＳ３０４）。判定結果が「ＮＯ」（冷却液入口温度Ｔ１が８０°Ｃ以上）である場合は、ウォーターポンプ１５の出力を増大して（ステップＳ３０５）、本ルーチンの実行を一旦終了する。これにより、冷却液の循環量が増大し、冷却液入口温度Ｔ１は下げる方向に制御されることとなる。

【００６１】ステップＳ３０４における判定結果が「ＹＥＳ」（冷却液入口温度Ｔ１が８０°Ｃ未満）である場合は、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１の温度差ΔＴを算出し（ステップＳ３０６）、算出された温度差ΔＴが目標温度差ΔＴαよりも小さいか否か判定する（ステップＳ３０７）。判定結果が「ＮＯ」（温度差ΔＴが目標温度差ΔＴα以上）である場合は、ウォーターポンプ１５の出力を増大して（ステップＳ３０５）、本ルーチンの実行を一旦終了する。これにより、冷却液の循環量が増大し、温度差ΔＴは小さくなる方向に制御されることとなる。

【００６２】ステップＳ３０７における判定結果が「ＹＥＳ」（温度差ΔＴが目標温度差ΔＴα未満）である場合は、ウォーターポンプ１５の出力を低減して（ステップＳ３０８）、本ルーチンの実行を一旦終了する。これにより、冷却液の循環量が減少し、温度差ΔＴは大きくなる方向に制御されることとなる。以上の温度制御処理を実行することにより、冷却液入口温度Ｔ１は８０°Ｃ以下に収束するようになり、且つ、温度差ΔＴは燃料電池１の出力に応じた目標温度差ΔＴαに収束するようになる。

【００６３】したがって、燃料電池１の出力が低いときには、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１との温度差ΔＴが小さい温度差に制御されるようになり、その結果、燃料電池１に流れる冷却液流量を比較的に大きくすることができるようになって、ヒートポイントを生じにくくすることができ、燃料電池１の損傷を防止することができる。一方、燃料電池１の出力が高いときには、冷却液出口温度Ｔ２と冷却液入口温度Ｔ１との温度差ΔＴが大きい温度差に制御されるようになり、その結果、燃料電池１に流れる冷却液流量を比較的に小さくすることができるようになって、ウォーターポンプ１５の消費電力を減少させることができ、燃料電池１の発電効率が向上する。

【００６４】なお、この第４の実施の形態の冷却装置においても、第１の実施の形態と同様の作用があり、したがって、燃料電池１に対する加湿性の向上、燃料電池１における水分排出性の向上、ウォーターポンプ１５の消費電力の減少を実現することができる。また、上述のように燃料電池１の出力に応じて目標温度差を変えて実行する冷却液の温度制御は、図６あるいは図８に示される構成の冷却装置にも適用可能である。

【００６５】

【発明の効果】以上説明するように、請求項１に記載した発明によれば、オフガスの燃料電池出口温度を高くすることができ、その結果、オフガスの露点を高くすることができ、オフガス中に気相（水蒸気）で存在する水分量を増大させて、これをオフガスとともに燃料電池から排出することができるので、燃料電池における水分の排出性が向上するという優れた効果が奏される。さらに、請求項１に記載した発明によれば、冷却液出口温度を高めに制御するようになることから、冷却液の循環量を減少させることができるので、循環ポンプの消費電力を減少させることができるという効果もある。

【００６６】また、請求項２に記載した発明によれば、オフガスの燃料電池出口温度を高くすることができ、その結果、オフガスの露点を高くすることができ、オフガス中に気相（水蒸気）で存在する水分量を増大させて、これをオフガスとともに燃料電池から排出することができるので、燃料電池における水分の排出性が向上するという優れた効果が奏される。

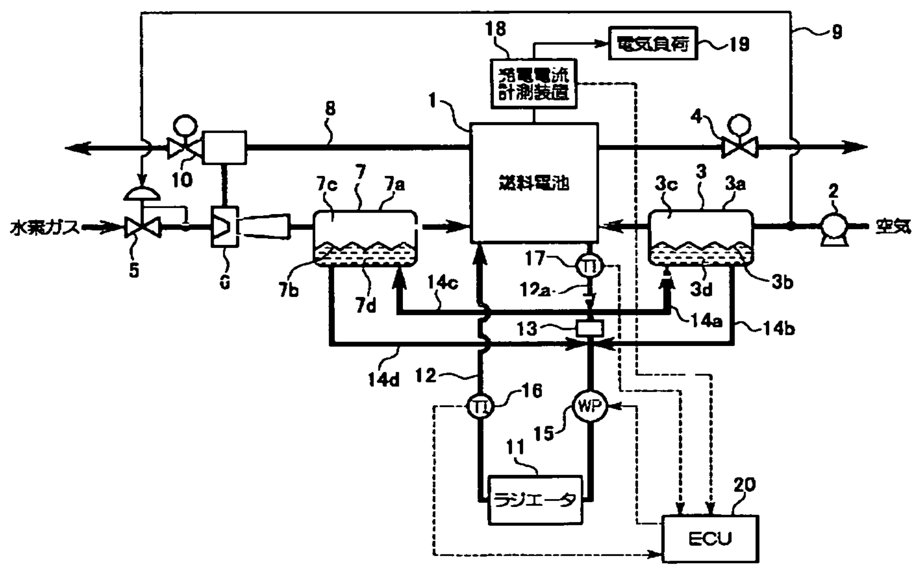
【００６７】また、請求項２に記載した発明によれば、加熱手段が冷却液で加湿器を加熱しているので、燃料電池に供給される反応ガスの温度が高まり、加湿器における反応ガスに対する加湿が促進され、しかも、加熱・加湿された反応ガスは燃料電池に供給された直後に冷却液によって冷却され、反応ガス中の蒸気が凝結して液状になり易くなり、燃料電池を加湿し易くなるので、燃料電池に対する加湿性が向上するという優れた効果が奏される。

【００６８】さらに、請求項２に記載した発明によれば、冷却液出口温度を高めに制御するようになることから、冷却液の循環量を減少させることができるので、循環ポンプの消費電力を減少させることができるという効果もある。

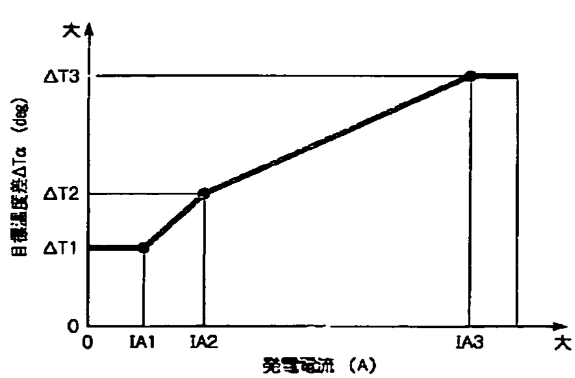
【００６９】請求項３に記載した発明によれば、燃料電池が低出力のときには、冷却液出口温度と冷却液入口温度との温度差を小さく設定して、燃料電池を流れる冷却液流量を増加させることができるので、燃料電池内にヒートポイントを生じにくくすることができ、燃料電池の損傷を防止することができ、一方、燃料電池が高出力のときには、冷却液出口温度と冷却液入口温度との温度差を大きく設定して、燃料電池を流れる冷却液流量を減少させることができるので、循環ポンプの消費電力を減少させることができ、燃料電池の発電効率が向上するという優れた効果が奏される。

【図面の簡単な説明】
【図１】　この発明に係る燃料電池の冷却装置における第１の実施の形態の概略構成図である。
【図２】　第１の実施の形態における燃料電池の概略断面図である。
【図３】　第１の実施の形態における燃料電池の反応ガス通路および冷却液通路の模式図である。
【図４】　第１の実施の形態における冷却液の温度制御フローチャートである。
【図５】　燃料電池の反応ガス通路および冷却液通路の他の例を示す模式図である。
【図６】　この発明に係る燃料電池の冷却装置における第２の実施の形態の概略構成図である。
【図７】　第１の実施の形態における冷却液の温度制御フローチャートである。
【図８】　この発明に係る燃料電池の冷却装置における第３の実施の形態の概略構成図である。
【図９】　この発明に係る燃料電池の冷却装置における第４の実施の形態の冷却液温度制御フローチャートである。
【図１０】　第４の実施の形態における目標温度差マップの一例である。
【符号の説明】
１　燃料電池
３　カソード加湿器
３ｄ，７ｄ　第２室（加熱手段）
３ｅ，７ｅ　ウォータージャケット（加熱手段）
７　アノード加湿器
１１　ラジエータ（放熱器）
１２　冷却液回路（冷却手段）
１５　ウォーターポンプ（循環ポンプ）
５８　冷却液通路（冷却手段）
ステップＳ１０３，１０５，１０６　制御手段
ステップＳ２０８，２０９，２１０　制御手段

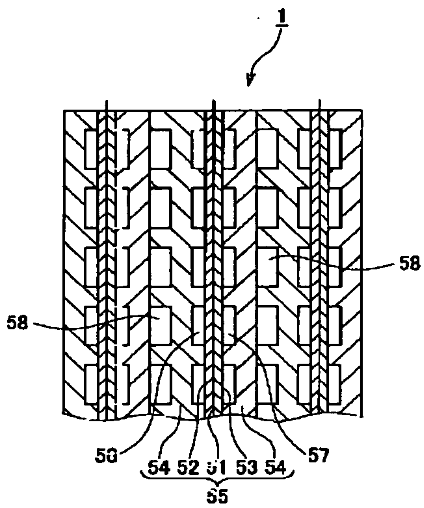
【図１】



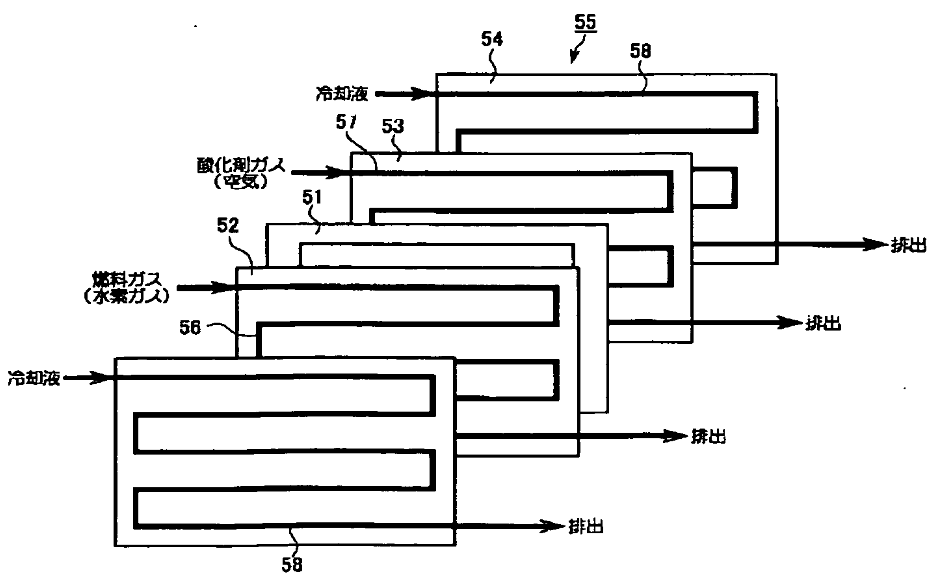
【図１０】



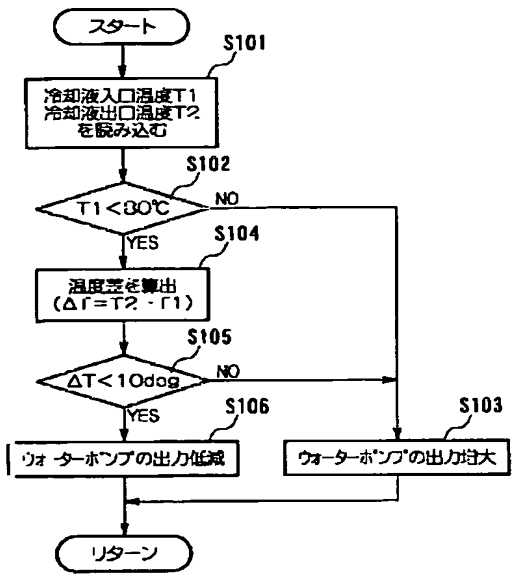
【図2】


1
58
58
56
54 52 51 53 54
55
57

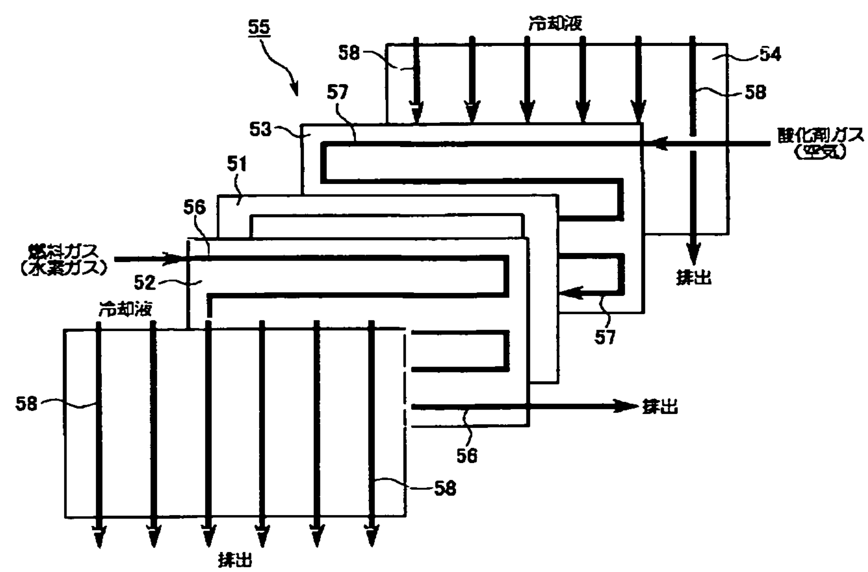
【図3】


54
55
58
冷却液
57
53
酸化剤ガス
(空気)
51
52
燃料ガス
(水素ガス)
56
冷却液
排出
排出
排出
排出
58

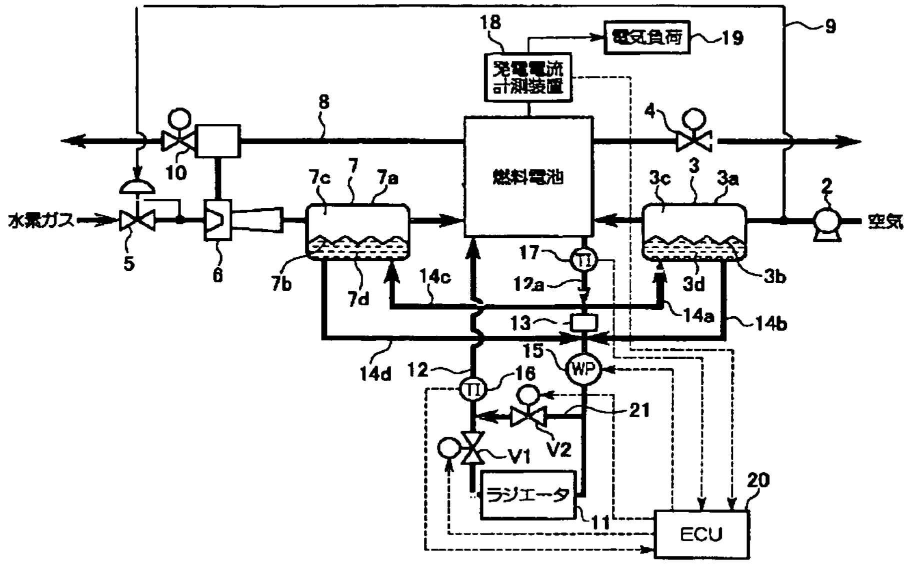
【図4】


スタート
S101
冷却液入口温度T1
冷却液出口温度T2
を読み込む
S102
T1＜80℃
NO
YES
S104
温度差を算出
(ΔT=T2－T1)
S105
ΔT＜10deg
NO
YES
S106
ウォーターポンプの出力低減
S103
ウォーターポンプの出力増大
リターン

【図5】

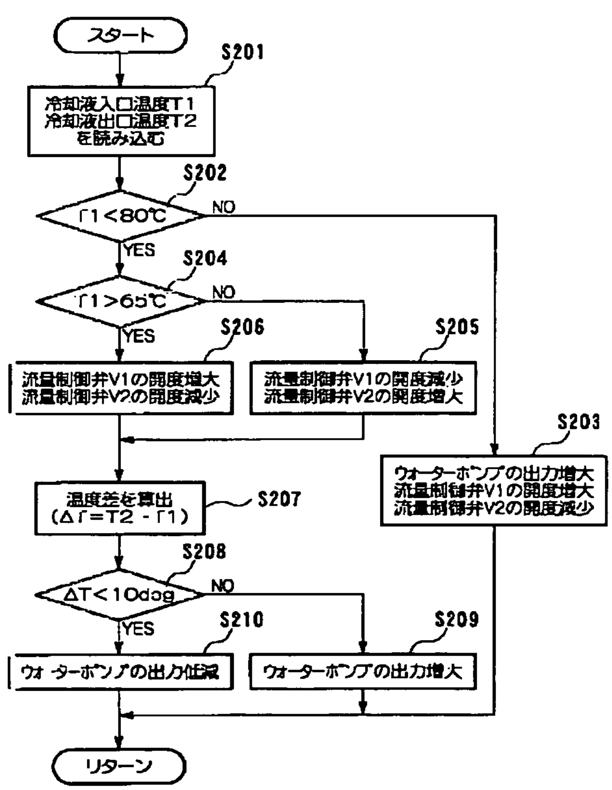

55
冷却液
58
54
58
57
53
酸化剤ガス
(空気)
51
56
燃料ガス
(水素ガス)
52
冷却液
排出
57
58
排出
56
58
排出

【図6】



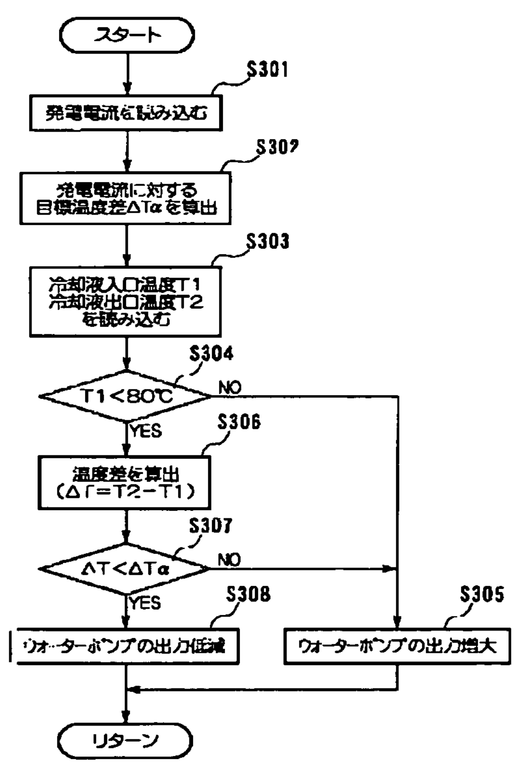
18
電気負荷
19
9
発電電流計測装置
8
4
10
燃料電池
7c
7
7a
3c
3
3a
2
水素ガス
空気
5
6
7b
7d
14c
17
12a
3d
3b
14a
13
14b
14d
12
15
WP
16
21
V1
V2
ラジエータ
11
20
ECU

【図7】



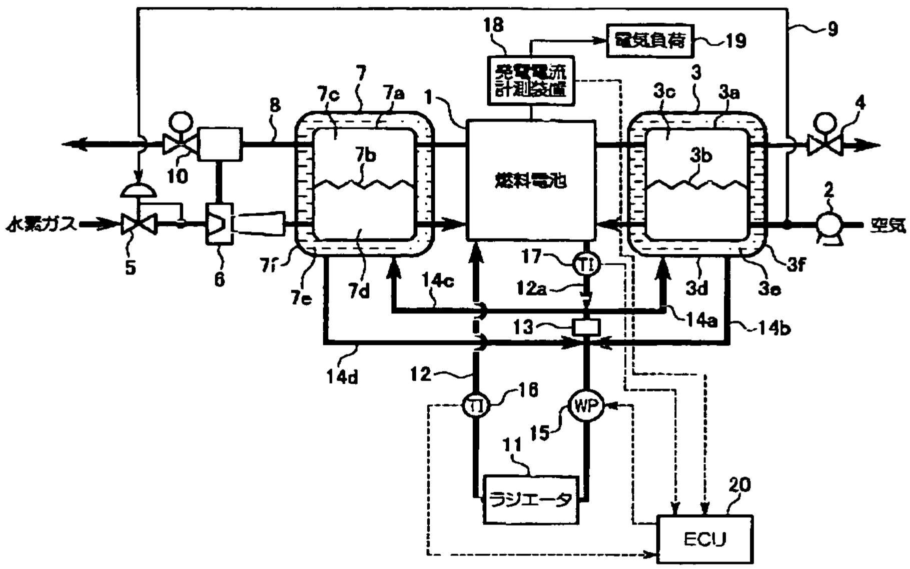
スタート
S201
冷却液入口温度T1
冷却液出口温度T2
を読み込む
S202
T1<80℃
NO
YES
S204
T1>65℃
NO
YES
S206
S205
流量制御弁V1の開度増大
流量制御弁V2の開度減少
流量制御弁V1の開度減少
流量制御弁V2の開度増大
S203
ウォーターポンプの出力増大
流量制御弁V1の開度増大
流量制御弁V2の開度減少
温度差を算出
(ΔT=T2－T1)
S207
S208
ΔT<10deg
NO
YES
S210
S209
ウォーターポンプの出力低減
ウォーターポンプの出力増大
リターン

【図9】



スタート
S301
発電電流を読み込む
S302
発電電流に対する
目標温度差ΔTαを算出
S303
冷却液入口温度T1
冷却液出口温度T2
を読み込む
S304
T1<80℃
NO
YES
S306
温度差を算出
(ΔT=T2－T1)
S307
ΔT<ΔTα
NO
YES
S308
S305
ウォーターポンプの出力低減
ウォーターポンプの出力増大
リターン

【図8】



フロントページの続き

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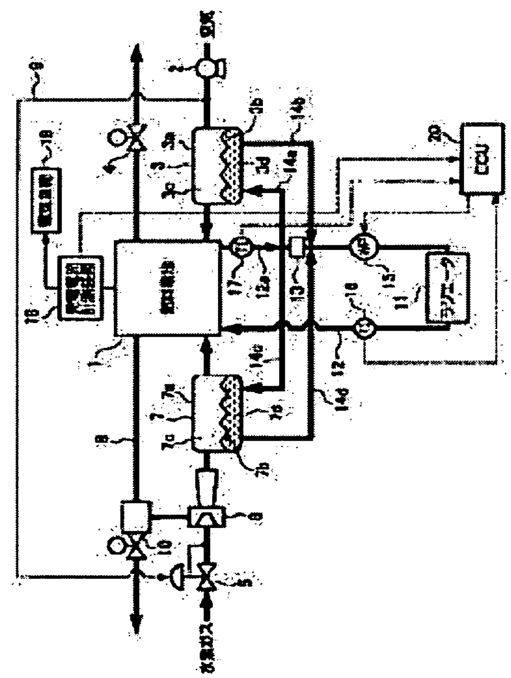
(54) COOLING DEVICE FOR FUEL CELL

(57)Abstract:
PROBLEM TO BE SOLVED: To aim at an improvement of humidifying property and moisture exhausting property of a fuel cell.
SOLUTION: The cooling device for a fuel cell comprises a fuel cell 1 generating electricity by using hydrogen and air as reaction gases; a humidifiers 3, 7 humidifying the reaction gases to be supplied to the fuel cell 1; a cooling liquid circuit 12, cooling the fuel cell 1 by making cooling liquid circulate between the fuel cell 1 and a radiation device 11 by a water pump 15, and radiating the heat of the cooling liquid to outside by a radiator 11; a heating means (3d, 7d), heating the humidifiers 3, 7 by the cooling liquid exhausted from the fuel cell 1; and a controlling means controlling the water pump 15 so as to keep a prescribed temperature difference between the temperature at the outlet and at the inlet of the cooling liquid of the fuel cell 1.



CLAIMS

[Claim(s)]
[Claim 1]A cooling system of a fuel cell characterized by comprising the following.
A fuel cell which generates electricity by making fuel gas and oxidant gas into reactant gas.
A cooling method which is made to circulate through cooling fluid between said fuel cell and a radiator with a circulating pump, pours cooling fluid to said reactant gas and an abbreviated uniform direction within said fuel cell, cools this fuel cell, and radiates heat outside in heat from cooling fluid with said radiator, A control means which controls said circulating pump so that a predetermined temperature gradient is secured between cooling liquid outlet temperature of said fuel cell, and cooling fluid inlet temperature.

[Claim 2]A cooling system of a fuel cell characterized by comprising the following.
A fuel cell which generates electricity by making fuel gas and oxidant gas into reactant gas.
A humidifier which humidifies said reactant gas supplied to said fuel cell.
A cooling method which is made to circulate through cooling fluid between said fuel cell and a radiator with a circulating pump, pours cooling fluid to said reactant gas and an abbreviated uniform direction within said fuel cell, cools this fuel cell, and radiates heat outside in heat from cooling fluid with said radiator.
A control means which controls said circulating pump so that a predetermined temperature gradient is secured between a heating method which heats said humidifier with said cooling fluid discharged from said fuel cell, and cooling liquid outlet temperature of said fuel cell and cooling fluid inlet temperature.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the cooling system of a fuel cell.
In particular, it is related with the cooling system of liquid cooling.

[0002]
[Description of the Prior Art]In the fuel cell carried in a fuel cell electric vehicle etc. For example, it consists of a stack constituted by carrying out the plural laminates of the cell which put the solid polyelectrolyte membrane which consists of a solid polymer ion-exchange membrane etc. from both sides with the anode and the cathode, and was formed, Some are provided with the hydrogen gas passage to which hydrogen gas is supplied as fuel gas, the air duct to which the air which contains oxygen as oxidant gas is supplied, and the coolant path to which cooling fluid is supplied. Hereafter, fuel gas and oxidant gas are named generically and it is called reactant gas. In this fuel cell, solid polyelectrolyte membrane is passed, even a cathode moves, the hydrogen ion generated by catalytic reaction in the anode causes and generates oxygen and electrochemical reaction with a cathode, and water is generated in that case.
[0003]By the way, since there is an operating temperature range in a fuel cell, it is necessary to cool, although generation of heat is followed on power generation of a fuel cell so that a fuel cell may not carry out temperature up more than upper limit temperature. Therefore, the cooling system which pours a refrigerant, takes heat and cools a fuel cell is formed in said coolant path of the fuel cell. There is a thing it was made to circulate the cooling fluid as a refrigerant between a fuel cell and a radiator (radiator) with a circulating pump in the cooling system of this fuel cell as indicated by JP,H10-340734,A. In this cooling system, when the cooling fluid which took heat from the fuel cell and was heated flows through a radiator, heat was radiated in the open air in the heat of cooling fluid, and cooling fluid is cooled.
[0004]The circulating load of cooling fluid was controlled so that it was made desirable to cool so that the internal temperature of a fuel cell may become uniform, therefore it decreased a temperature gradient with the cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature as much as possible on a system conventionally, as indicated by said gazette.
[0005]
[Problem(s) to be Solved by the Invention]However, lessening a temperature gradient with the cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature in this way, Since it is carrying out in the direction which lowers cooling liquid outlet temperature, therefore the circulating load of cooling fluid will be increased and the power consumption of the circulating pump increased, it was disadvantageous on energy management.
[0006]As mentioned above, although water is generated when generating electricity, this water has some which exist by the gaseous phase as a steam in unreacted reactant gas, i.e., off-gas, and a fuel cell has some which serve as a fluid, dissociate from off-gas, and exist by the liquid phase. Since the moisture which exists in off-gas as a steam is discharged from a fuel cell with off-gas, it does not become a problem, but a liquefied thing has a possibility of blocking a part of reactant gas way depending on the case, and a desirable gestalt cannot be said. Then,

considering the viewpoint of discharge of the moisture of produced water etc., since the moisture content which the one where the internal temperature of a fuel cell is higher can get the dew point, can make contain many moisture in off-gas by the gaseous phase (steam), and can discharge with off-gas can be increased, it is desirable. However, since it was controlling in the direction which lessens a temperature gradient with the cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature, and lowers cooling liquid outlet temperature as conventionally mentioned above, the moisture in off-gas became the liquid phase easily, and there was room of improvement in respect of the eccritic nature of moisture.
[0007]On the other hand, in the fuel cell using solid polyelectrolyte membrane. In order to secure the ion conductivity of solid polyelectrolyte membrane to a predetermined state and to maintain a good power generation state, The reactant gas (hydrogen gas and air) supplied to a fuel cell is humidified with the humidifier, and when this humidified reactant gas condenses within a fuel cell and adheres to solid polyelectrolyte membrane, the ion conductivity of solid polyelectrolyte membrane is raised. Thus, considering the viewpoint of the humidification to a fuel cell, it will be easy to solidify the steam in reactant gas, and the one where the internal temperature of a fuel cell is lower will be preferred. It was very difficult to reconcile the humidification nature to a fuel cell, and the eccritic nature of the moisture mentioned above, and to control the internal temperature of a fuel cell from such a situation.
[0008]Then, this invention provides the cooling system of the fuel cell excellent in the eccritic nature of the moisture in a fuel cell by securing a temperature gradient positively to the internal temperature distribution in the fuel cell of the structure where the flow direction of cooling fluid was made reactant gas in the abbreviated uniform direction. This invention by securing a temperature gradient positively to the internal temperature distribution in the fuel cell of the structure where the flow direction of cooling fluid was made reactant gas in the abbreviated uniform direction, The cooling system of the fuel cell which can aim at coexistence of improvement in the wastewater nature of the moisture in a fuel cell and improvement in the humidification nature to solid polyelectrolyte membrane is provided.
[0009]
[Means for Solving the Problem]In order to solve an aforementioned problem, an invention indicated to Claim 1, A fuel cell (for example, fuel cell 1 in each embodiment mentioned later) which generates electricity by making into reactant gas fuel gas (for example, hydrogen gas in each embodiment mentioned later), and oxidant gas (for example, air in each embodiment mentioned later), Cooling fluid with a circulating pump (for example, water pump 15 in each embodiment mentioned later) Said fuel cell and a radiator. It is made to circulate between (for example, the radiators 11 in each embodiment mentioned later), A cooling method (for example, coolant circuits 12 in each embodiment mentioned later) which pours cooling fluid to said reactant gas and an abbreviated uniform direction within said fuel cell, cools this fuel cell, and radiates heat outside in heat from cooling fluid with said radiator, A control means which controls said circulating pump so that a predetermined temperature gradient is secured between cooling liquid outlet temperature of said fuel cell, and cooling fluid inlet temperature. for example, the step S103,105,106 in a 1st embodiment mentioned later -- and, It is a cooling system of a fuel cell provided with Step S208,209,210 in a 2nd embodiment, and Step S305,307,308 in a 4th embodiment.
[0010]By constituting in this way, by control of a circulating pump by said control means. Since a predetermined temperature gradient is secured between cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature, Cooling liquid outlet temperature will be controlled by slight height, and further from reactant gas and cooling fluid flowing into an abbreviated uniform direction within a fuel cell. Fuel cell outlet temperature of unreacted reactant gas (henceforth off-gas) can be made high, as a result, the dew point of off-gas can be made high, and it becomes possible to increase a moisture content which exists by the gaseous phase (steam) in off-gas. Since it comes to control cooling liquid outlet temperature more highly, a circulating load of cooling fluid can be decreased.
[0011]An invention indicated to Claim 2 Fuel gas (for example, hydrogen gas in each embodiment mentioned later), and oxidant gas. A fuel cell (for example, fuel cell 1 in each embodiment

mentioned later) which generates electricity by making (for example, air in each embodiment mentioned later) into reactant gas, A humidifier (for example, the cathode humidifier 3 and the anode humidifier 7 in each embodiment mentioned later) which humidifies said reactant gas supplied to said fuel cell, Cooling fluid with a circulating pump (for example, water pump 15 in each embodiment mentioned later) Said fuel cell and a radiator. It is made to circulate between (for example, the radiators 11 in each embodiment mentioned later), A cooling method (for example, coolant circuits 12 in each embodiment mentioned later) which pours cooling fluid to said reactant gas and an abbreviated uniform direction within said fuel cell, cools this fuel cell, and radiates heat outside in heat from cooling fluid with said radiator, A heating method (for example, water jackets [in / the 2nd room / 3d, 7d and a 3rd embodiment] 3e and 7e in a 1st and 2nd embodiment mentioned later) which heats said humidifier with said cooling fluid discharged from said fuel cell, A control means which controls said circulating pump so that a predetermined temperature gradient is secured between cooling liquid outlet temperature of said fuel cell, and cooling fluid inlet temperature. for example, the step S103,105,106 in a 1st embodiment mentioned later -- and, It is a cooling system of a fuel cell provided with Step S208,209,210 in a 2nd embodiment, and Step S305,307,308 in a 4th embodiment.

[0012]By constituting in this way, by control of a circulating pump by said control means. Since a predetermined temperature gradient is secured between cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature, Cooling liquid outlet temperature will be controlled by slight height, and further from reactant gas and cooling fluid flowing into an abbreviated uniform direction within a fuel cell. Fuel cell outlet temperature of off-gas can be made high, as a result, the dew point of off-gas can be made high, and it becomes possible to increase a moisture content which exists by the gaseous phase (steam) in off-gas.

[0013]Since a heating method is heating a humidifier with cooling fluid, temperature of reactant gas supplied to a fuel cell is risen, and humidification to reactant gas in a humidifier is promoted. And a predetermined temperature gradient is secured between cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature, Within a fuel cell, since reactant gas and cooling fluid flow into an abbreviated uniform direction, it is cooled with cooling fluid immediately after supplying a fuel cell, and a steam in reactant gas solidifies reactant gas heated and humidified with said humidifier, it becomes liquefied easily, and becomes easy to humidify a fuel cell. Since it comes to control cooling liquid outlet temperature more highly, a circulating load of cooling fluid can be decreased.

[0014]An invention indicated to Claim 3 changes a desired value of said temperature gradient in the invention according to claim 1 or 2 according to an output of said fuel cell. When a fuel cell is low-power output by constituting in this way, Set up small a temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature, and it becomes possible to make a cooling fluid flow which flows through a fuel cell increase, and on the other hand, when a fuel cell is high power, It becomes possible to set up greatly a temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature, and to decrease a cooling fluid flow which flows through a fuel cell.

[0015]

[Embodiment of the Invention]Hereafter, the embodiment of the cooling system (it may only be called a cooling system) of the fuel cell concerning this invention is described with reference to the Drawings of drawing 10 from drawing 1. The embodiment described below is the mode applied to the cooling system of the fuel cell carried in a fuel cell electric vehicle.

[0016][A 1st embodiment] A 1st embodiment of the cooling system of the fuel cell concerning this invention is described with reference to the Drawings of drawing 5 from drawing 1. Drawing 1 is an outline lineblock diagram of a cooling system. The fuel cell 1 used as introduction and a cooling object is explained. As the fuel cell 1 is a solid polyelectrolyte membrane type fuel cell and it is shown in drawing 2, For example, the solid polyelectrolyte membrane 51 which consists of a solid polymer ion-exchange membrane etc. is put from both sides with the anode 52 and the cathode 53, The hydrogen gas passage 56 which it becomes from the stack constituted by carrying out the plural laminates of the cell 55 which furthermore pinched the outside with the separators 54 and 54 of the couple, and was formed and to which hydrogen gas is supplied as

fuel gas, It has the air duct 57 to which the air which contains oxygen as oxidant gas is supplied, and the coolant path 58 to which cooling fluid is supplied. And the solid polyelectrolyte membrane 51 is passed, even the cathode 53 moves, the hydrogen ion generated by catalytic reaction in the anode 52 causes and generates oxygen and electrochemical reaction with the cathode 53, and water is generated in that case. With the cooling fluid which flows through said coolant path 58, heat is taken and it cools so that the fuel cell 1 may not exceed upper limit temperature by generation of heat accompanying this power generation.
[0017]In this fuel cell 1, the hydrogen gas passage 56, the air duct 57, and the coolant path 58 are mutually parallel, and are provided. Drawing 3 is a perspective view showing these passages 56, 57, and 58 typically, and these passages 56, 57, and 58 are moved in a zigzag direction and established in the same gestalt by each from the entrance of the upper left part of the cell 55 to the exit of a lower right part. Therefore, in this embodiment, the hydrogen gas passage 56, the air duct 57, and the coolant path 58 cover that overall length, and the flow direction of each fluid is made into the uniform direction.
[0018]Next, a cooling system is explained in accordance with the flow of each fluid. After having been pressurized by the air compressor 2, being humidified with the cathode humidifier 3, supplying the air duct 57 of the fuel cell 1 and presenting power generation with oxygen in this air as an oxidizer, the open air is discharged as air off-gas from the fuel cell 1, and is emitted to the atmosphere via the pressure control valve 4. Revolving speed control of the air compressor 2 is carried out so that the air of the mass according to the output demanded of the fuel cell 1 may be supplied to the fuel cell 1, and opening control of the pressure control valve 4 is carried out so that the air supply pressure to the fuel cell 1 may serve as a pressure value according to the operational status of the fuel cell 1.
[0019]As for the cathode humidifier 3, the inside of the casing 3a is isolated by two upper and lower sides with the water-vapor-permeation film 3b, The upper cooling fluid discharged from the fuel cell 1 so that the 1st room of air duct 57 entrance of the air compressor 2 and the fuel cell 1 might be connected to 3c and it might mention later to lower 3d of room [2nd] circulates. The water-vapor-permeation film 3b has the function to make only a steam penetrate bordering on this water-vapor-permeation film 3b to the one where water vapor pressure is lower from the one where water vapor pressure is higher.
[0020]After the hydrogen gas emitted from the high pressure hydrogen tank which is not illustrated on the other hand is decompressed by the fuel supply control valve 5, it passes along the ejector 6, is humidified with the anode humidifier 7, and is supplied to the hydrogen gas passage 56 of the fuel cell 1. After power generation is presented with this hydrogen gas, unreacted hydrogen gas is discharged as hydrogen off-gas from the fuel cell 1, is attracted by the ejector 6 through the hydrogen off-gas recovery passage 8, joins the hydrogen gas supplied from said high pressure hydrogen tank, and is again supplied to the fuel cell 1.
[0021]The fuel supply control valve 5 consists of a proportional pressure control valve of an air type, for example, and is inputted via the pneumatic-signal introducing path 9 by making into signal pressure the pressure of the air supplied from the air compressor 2, and pressure reduction control is carried out so that the pressure of hydrogen gas of fuel supply control valve 5 exit may serve as a specified pressure range according to said signal pressure. The hydrogen off-gas recovery passage 8 is provided with the purge valve 10, and when a predetermined condition is fulfilled, valve-opening control is carried out, and it drains the purge valve 10 to the exterior so that the hydrogen gas passage 56 of the fuel cell 1 may not be covered with water.
[0022]The anode humidifier 7 is making the same structure as the cathode humidifier 3, the inside of the casing 7a is isolated by two upper and lower sides with the water-vapor-permeation film 7b -- the upper 1st -- room 7c -- the ejector 6 -- and -- and hydrogen gas passage 56 entrance of the fuel cell 1 is connected, and the cooling fluid discharged from the fuel cell 1 so that it might mention later circulates to lower 7d of room [2nd]. Here, said cathode humidifier 3 humidifies air with the steam of the cooling fluid which penetrated the water-vapor-permeation film 3b, supplies the humidified air to the fuel cell 1, and the anode humidifier 7 humidifies hydrogen gas with the steam of the cooling fluid which penetrated the water-vapor-permeation film 7b, and it supplies the humidified hydrogen gas to the fuel cell 1. Thereby, the ion

conductivity of the solid polyelectrolyte membrane of the fuel cell 1 is secured to a predetermined state.

[0023]The cooling fluid for cooling the fuel cell 1, Pressure up is carried out by the water pump (WP) 15 which is a circulating pump, and the radiator (radiator) 11 is supplied, Cooling fluid is cooled by radiating heat outside in the radiator 11, Then, the fuel cell 1 is supplied, when it passes along the coolant path 58 in the fuel cell 1, heat is taken from the fuel cell 1, the fuel cell 1 is cooled, and via the water pump 15, again, the cooling fluid heated by this returns to the radiator 11, and is cooled. That is, cooling fluid circulates through the coolant circuits (cooling method) 12 which connect the fuel cell 1, the water pump 15, and the radiator 11 to a closed circuit.

[0024]The restriction orifice 13 is formed in the cooling fluid mainstream way (namely, cooling fluid passage which is the lower stream of the fuel cell 1 and is located upstream of the water pump 15) 12a which goes to the water pump 15 from the fuel cell 1 in the coolant circuits 12. On the cooling fluid mainstream way 12a, it is the upper stream (namely, fuel cell 1 slippage) and the lower stream (.) of the orifice 13. That is, radiator 11 slippage is connected to 7 d of the anode humidifier 7 of room [2nd] by the cooling fluid sub passages 14c and 14d, respectively while being connected to 3 d of the cathode humidifier 3 of room [2nd] by the cooling fluid sub passages 14a and 14b. Thereby, some cooling fluid which flows through the cooling fluid mainstream way 12a is introduced into 7 d of 2nd room 3d and the anode humidifier 7 of the cathode humidifier 3 of room [2nd] through the cooling fluid sub passages 14a and 14c, and it returns to the cooling fluid mainstream way 12a through the cooling fluid sub passages 14b and 14d. In this 1st embodiment, 3 d of the cathode humidifier 3 of room [2nd], and 7 d of the anode humidifier 7 of room [2nd] constitutes a heating method.

[0025]In the coolant circuits 12, to the entrance side of the fuel cell 1. The inlet temperature sensor (TI) 16 which detects the temperature (henceforth cooling fluid inlet temperature) of the cooling fluid supplied to the fuel cell 1 is formed, In the coolant circuits 12, the outlet temperature sensor (TI) 17 which detects the temperature (henceforth cooling liquid outlet temperature) of the cooling fluid discharged from the fuel cell 1 is formed in the outlet side of the fuel cell 1. The electronic control unit (it abbreviates to ECU hereafter) 20 controls the output of the water pump 15 based on the output signal of these temperature sensors 16 and 17.

[0026]The power generation current taken out from the fuel cell 1 is connected to the electric loads 19, such as a motor which drives a drive motor and the air compressor 2, via the power-generation-current metering device 18 which measures power generation current.

[0027]Next, an operation of the cooling system of the fuel cell in this 1st embodiment is explained. If the cooling liquid outlet temperature of the fuel cell 1 puts in another way so that only prescribed temperature may become high rather than cooling fluid inlet temperature, the output of the water pump 15 will be controlled by the cooling system in this embodiment so that a prescribed temperature difference is secured between cooling liquid outlet temperature and cooling fluid inlet temperature. Drawing 4 sets upper limit temperature of cooling fluid inlet temperature to 80 degreeC, shows the temperature control flow chart of the cooling fluid at the time of setting a target temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature to 10degree (it abbreviates to "deg" hereafter), and explains temperature control processing according to this.

[0028]First, the cooling fluid inlet temperature T1 and the cooling liquid outlet temperature T2 which were detected with the inlet temperature sensor 16 and the outlet temperature sensor 17 are read (Step S101), and it is judged whether the cooling fluid inlet temperature T1 is lower than upper limit temperature (80degreeC) (Step S102). When a decision result is "NO" (the cooling fluid inlet temperature T1. more than 80 degreeC), the output of the water pump 15 is increased (Step S103), and execution of this routine is once ended. By this, the circulating load of cooling fluid will increase and the cooling fluid inlet temperature T1 will be controlled in the direction to lower.

[0029]When the decision result in Step S102 is "YES" (the cooling fluid inlet temperature T1. less than 80 degreeC), Temperature-gradient deltaT of the cooling liquid outlet temperature T2

and the cooling fluid inlet temperature T1 is computed (Step S104), and it is judged whether computed temperature-gradient deltaT is smaller than a target temperature gradient (10deg) (Step S105). When a decision result is "NO" (deltaT10 or more deg of temperature gradients), the output of the water pump 15 is increased (Step S103), and execution of this routine is once ended. By this, the circulating load of cooling fluid will increase and temperature-gradient deltaT will be controlled in the direction which becomes small.

[0030]When the decision result in Step S105 is "YES" (less than deltaT10 deg of temperature gradients), the output of the water pump 15 is reduced (Step S106), and execution of this routine is once ended. By this, the circulating load of cooling fluid will decrease and temperature-gradient deltaT will be controlled in the direction which becomes large. By performing the above temperature control processing, it comes to converge below on 80 degreeC, and temperature-gradient deltaT comes to converge the cooling fluid inlet temperature T1 on a target temperature gradient (10deg). When coolant temperature is controlled in this way, the cooling liquid outlet temperature T2 will be controlled in the range in which the cooling fluid inlet temperature T1 does not exceed upper limit temperature by slight height.

[0031]And since the cooling fluid which took and carried out the rise in heat of the heat from the fuel cell 1 is supplied to 3 d of the cathode humidifier 3 of room [2nd], the air in the 1st room 3c of the cathode humidifier 3 is heated, the relative humidity of this air falls, and the dew point of this air can be raised in this cooling system. As a result, some cooling fluid in the 2nd room 3d serves as a steam, it penetrates the water-vapor-permeation film 3b, and promotes the humidification to the air in the 1st room 3c.

[0032]And temperature control is carried out so that a predetermined temperature gradient (target temperature-gradient 10deg) may be secured between the cooling liquid outlet temperature T2 of the fuel cell 1, and the cooling fluid inlet temperature T1, The cooling fluid entrance position and air inlet position in the fuel cell 1 are the same, since the flow direction is a uniform direction, it will be cooled with cooling fluid immediately after supplying the fuel cell 1, and the steam in this air solidifies the air heated and humidified with the cathode humidifier 3, and it becomes liquefied easily. As a result, it becomes easy to humidify the solid polyelectrolyte membrane 51 of the fuel cell 1.

[0033]The same may be said of the anode humidifier 7, and the humidification to the air in the 1st room 7c is promoted by supplying the cooling fluid discharged from the fuel cell 1 to 7 d of the anode humidifier 7 of room [2nd]. And since it is cooled with cooling fluid immediately after supplying the fuel cell 1, the steam in hydrogen gas solidifies the hydrogen gas heated and humidified with the anode humidifier 7, it becomes liquefied easily, and becomes easy to humidify the solid polyelectrolyte membrane 51. Therefore, the ion conductivity of the solid polyelectrolyte membrane 51 comes to be certainly secured to a predetermined state, and the humidification nature to the fuel cell 1 improves.

[0034]Since heat exchange is performed while the cooling liquid outlet temperature T2 is controlled in the range in which the cooling fluid inlet temperature T1 does not exceed upper limit temperature by slight height and hydrogen gas and air, and cooling fluid flow into a uniform direction within the fuel cell 1 further, Temperature in fuel cell 1 exit of hydrogen off-gas and air off-gas can be made high. As a result, the dew point of these off-gas can be made high, and the moisture content which exists by the gaseous phase (steam) in off-gas can be increased. Therefore, the eccritic nature of the moisture in the fuel cell 1 improves, and a water blockade becomes difficult to take place in the hydrogen gas passage 56 and the air duct 57.

[0035]Since the cooling liquid outlet temperature T2 is controlled more highly, the circulating load of cooling fluid can be decreased and the power consumption of the water pump 15 can be decreased.

[0036]Arrangement of the hydrogen gas passage 56 in the fuel cell 1, the air duct 57, and the coolant path 58 is not restricted to the gestalt shown in drawing 3. For example, as shown in drawing 5, from the entrance of the upper left part of the cell 55, toward the exit of a lower right part, the hydrogen gas passage 56 winds and is provided, From the entrance of the upper right portion of the cell 55, the air duct 57 winds, and may be provided toward the exit of a left lower quadrant, and the coolant path 58 may be linearly formed toward the lower part from the upper

part of the cell 55. In this case, though it moves [hydrogen gas and air] in a zigzag direction, since it is flowing toward the low rank from the higher rank of the cell 55, it can be said that that flow direction is the flow direction and abbreviated uniform direction of cooling fluid through which it flows toward the bottom from a top.
[0037][A 2nd embodiment] Next, a 2nd embodiment of the cooling system of the fuel cell concerning this invention is described with reference to the Drawings of drawing 6 and drawing 7. The point that the cooling system in a 2nd embodiment is different from the thing of a 1st embodiment is as follows. It is the lower stream of the radiator 11 and the flow control valve V1 is formed in the coolant circuits 12 upstream of the inlet temperature sensor 16. The bypass channel 21 which connects the lower stream of the water pump 15 and the upper stream of the inlet temperature sensor 16, and bypasses the radiator 11 and the flow control valve V1 is established in the coolant circuits 12, and the flow control valve V2 is formed in the bypass channel 21. Since it is the same as the thing of a 1st embodiment about other composition, identical codes are given to the same mode portion, and explanation is omitted.
[0038]ECU20 controls the output of the water pump 15, and the flow control valve V1 and the opening of V2 by the cooling system of this 2nd embodiment based on the output signal of the inlet temperature sensor 16 and the outlet temperature sensor 17. Drawing 7 sets upper limit temperature of cooling fluid inlet temperature to 80 degreeC, target temperature (henceforth target cooling fluid inlet temperature) of cooling fluid inlet temperature is set to 65 degreeC, and the temperature control flow chart of the cooling fluid at the time of setting a target temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature to 10deg is shown.
[0039]In the temperature control processing in this case, the cooling fluid inlet temperature T1 and the cooling liquid outlet temperature T2 which were detected with the inlet temperature sensor 16 and the outlet temperature sensor 17 are read first (Step S201), and it is judged whether the cooling fluid inlet temperature T1 is lower than upper limit temperature (80degreeC) (Step S202). When a decision result is "NO" (the cooling fluid inlet temperature T1. more than 80 degreeC), the output of the water pump 15 is increased, the opening of the flow control valve V1 is increased, the opening of the flow control valve V2 is decreased (Step S203), and execution of this routine is once ended. Since the flow of the cooling fluid which the flow of the cooling fluid which circulates through the fuel cell 1 increases, and the flow of the cooling fluid which passes the radiator 11 increases, and passes through the bypass channel 21 will decrease if it does in this way, the cooling fluid inlet temperature T1 will be controlled in the direction which falls quickly.
[0040]When the decision result in Step S202 is "YES" (the cooling fluid inlet temperature T1. less than 80 degreeC), it is judged whether the cooling fluid inlet temperature T1 is larger than target cooling fluid inlet temperature (65degreeC) (Step S204). When a decision result is "NO" (the cooling fluid inlet temperature T1. below 65 degreeC), the opening of the flow control valve V1 is decreased, and the opening of the flow control valve V2 is increased (Step S205). Since the flow of the cooling fluid which the flow of the cooling fluid which passes the radiator 11 decreases, and passes through the bypass channel 21 will increase if it does in this way, the cooling fluid inlet temperature T1 will be controlled in the direction which goes up.
[0041]When the decision result in Step S204 is "YES" (the cooling fluid inlet temperature T1 is higher than 65 degreeC), the opening of the flow control valve V1 is increased, and the opening of the flow control valve V2 is decreased (Step S206). Since the flow of the cooling fluid which the flow of the cooling fluid which passes the radiator 11 increases, and passes through the bypass channel 21 will decrease if it does in this way, the cooling fluid inlet temperature T1 will be controlled in the falling direction. That is, the cooling fluid inlet temperature T1 will be controlled by performing processing of Step S205 or Step S206 that it should converge on target cooling fluid inlet temperature (65degreeC).
[0042]It progresses to Step S207 after Step S205 or Step S206, temperature-gradient deltaT of the cooling liquid outlet temperature T2 and the cooling fluid inlet temperature T1 is computed, and it is judged whether computed temperature-gradient deltaT is smaller than a target temperature gradient (10deg) (Step S208). When a decision result is "NO" (deltaT10 or more deg

of temperature gradients), the output of the water pump 15 is increased (Step S209), and execution of this routine is once ended. By this, the circulating load of cooling fluid will increase and temperature-gradient deltaT will be controlled in the direction which becomes small.
[0043]When the decision result in Step S208 is "YES" (less than deltaT10 deg of temperature gradients), the output of the water pump 15 is reduced (Step S210), and execution of this routine is once ended. By this, the circulating load of cooling fluid will decrease and temperature-gradient deltaT will be controlled in the direction which becomes large. By performing the above temperature control processing, it comes to converge on 65 degreeC, and temperature-gradient deltaT comes to converge the cooling fluid inlet temperature T1 on a target temperature gradient (10deg). Also in the cooling system of this 2nd embodiment, there is the same operation as a 1st embodiment, therefore improvement in the humidification nature to the fuel cell 1, improvement in moisture eccritic nature in the fuel cell 1, and reduction of the power consumption of the water pump 15 can be realized.
[0044][A 3rd embodiment] Next, a 3rd embodiment of the cooling system of the fuel cell concerning this invention is described with reference to the Drawings of drawing 8. The following explanation is stopped only in the point of difference between a 3rd embodiment and a 1st embodiment, gives identical codes to the inside of a figure, and the same mode portion about the 1st thing and identical configuration portion of an embodiment, and omits explanation. According to a 3rd embodiment, the cathode humidifier 3 is formed ranging over the air supply course and the air off-gas course, and the anode humidifier 7 is formed ranging over the hydrogen gas feed route and the hydrogen off-gas course. If it explains in full detail, the cathode humidifier 3 is the lower stream of the air compressor 2 in an air supply course, and is formed upstream of the pressure control valve 4 in the air off-gas course. The anode humidifier 7 is the lower stream of the ejector 6 in a hydrogen gas feed route, and is formed upstream of the purge valve 10 in the hydrogen off-gas course.
[0045]Although the cathode humidifier 3 is the 1st cathode humidifier 3 and identical configuration of an embodiment in the point that the inside of the casing 3a is isolated by two upper and lower sides with the water-vapor-permeation film 3b, in a 3rd embodiment, air duct 57 entrance of the air compressor 2 and the fuel cell 1 is connected to lower 3 d of room [2nd] -- the upper part -- the 1st room of air duct 57 exit and the pressure control valve 4 of the fuel cell 1 are connected to 3c. therefore, the air off-gas which the air supplied from the air compressor 2 was supplied to the air duct 57 of the fuel cell 1 through 3 d of the cathode humidifier 3 of room [2nd], and was discharged from the fuel cell 1 -- the cathode humidifier 3 -- the 1st room will be discharged by the atmosphere from the pressure control valve 4 through 3c. The cathode humidifier 3 of a 3rd embodiment equips the outside of the casing 3a with the outer casing 3f which forms the water jacket 3e. And the cooling fluid sub passages 14a and 14b are connected to this water jacket 3e, and circulation of the water jacket 3e of the cooling fluid discharged from the fuel cell 1 is attained.
[0046]Therefore, in the cathode humidifier 3 of this 3rd embodiment, when the cooling fluid which took heat from the fuel cell 1 and carried out the rise in heat circulates through the water jacket 3e, the air off-gas in the air in the 2nd room 3d, and the 1st room 3c is heated. If the air in the 2nd room 3d is heated, the relative humidity of this air falls, the dew point of this air can be got, and the air in the 2nd room 3d will be in the state of being easy to be humidified. On the other hand, if the air off-gas in the 1st room 3c is heated, evaporation of the liquefied water contained in air off-gas can be promoted, The steam generated by this evaporation and the steam contained in air off-gas as the gaseous phase from the first penetrate the water-vapor-permeation film 3b, moves into the 2nd room 3d, and humidifies the air in the 2nd room 3d. That is, the humidification to the air in the 2nd room 3d can be promoted by circulating through cooling fluid with a high temperature to the water jacket 3e.
[0047]moreover -- the anode humidifier 7 as well as the cathode humidifier 3 is constituted, and hydrogen gas passage 56 entrance of the ejector 6 and the fuel cell 1 is connected to lower 7 d of room [2nd] -- the upper part -- the 1st room of hydrogen gas passage 56 exit and the hydrogen off-gas recovery passage 8 of the fuel cell 1 are connected to 7c. therefore, the hydrogen off-gas which the hydrogen gas supplied from the ejector 6 was supplied to the

hydrogen off-gas passage 56 of the fuel cell 1 through 7 d of the anode humidifier 7 of room [2nd], and was discharged from the fuel cell 1 -- the anode humidifier 7 -- the 1st room will be discharged by the hydrogen off-gas recovery passage 8 through 7c. And the cooling fluid sub passages 14c and 14d are connected to the water jacket 7e provided between the casing 7a and the outer casing 7f, and circulation of the water jacket 7e of the cooling fluid discharged from the fuel cell 1 is attained.

[0048]Therefore, in the anode humidifier 7 of this 3rd embodiment, when the cooling fluid which took heat from the fuel cell 1 and carried out the rise in heat circulates through the water jacket 7e, the hydrogen off-gas in hydrogen gas in the 2nd room 7d, and the 1st room 7c is heated. If hydrogen gas in the 2nd room 7d is heated, the relative humidity of this hydrogen gas falls, the dew point of this hydrogen gas can be got, and hydrogen gas in the 2nd room 7d will be in the state of being easy to be humidified. On the other hand, if the hydrogen off-gas in the 1st room 7c is heated, evaporation of the liquefied water contained in hydrogen off-gas can be promoted, The steam generated by this evaporation and the steam contained in hydrogen off-gas as the gaseous phase from the first penetrate the water-vapor-permeation film 7b, moves into the 2nd room 7d, and humidifies the air in the 2nd room 7d. That is, the humidification to hydrogen gas in the 2nd room 7d can be promoted by circulating through cooling fluid with a high temperature to the water jacket 7e. In this 3rd embodiment, the water jacket 3e of the cathode humidifier 3 and the water jacket 7e of the anode humidifier 7 constitute a heating method.

[0049]And also in the cooling system of this 3rd embodiment, like the case of a 1st embodiment, temperature control is carried out so that a predetermined temperature gradient (for example, target temperature-gradient 10deg) may be secured between the cooling liquid outlet temperature T2 of the fuel cell 1, and the cooling fluid inlet temperature T1. If it does in this way, same operation and the effect as the cooling system of a 1st embodiment can be acquired also with the cooling system of a 3rd embodiment.

[0050]Namely, temperature control is carried out so that a predetermined temperature gradient (target temperature-gradient 10deg) may be secured between the cooling liquid outlet temperature T2 of the fuel cell 1, and the cooling fluid inlet temperature T1, Since the cooling fluid entrance position and reactant gas entrance position in the fuel cell 1 are the same and the flow direction is a uniform direction, It will be cooled with cooling fluid immediately after supplying the fuel cell 1, and the steam in this reactant gas solidifies the reactant gas heated and humidified with the cathode humidifier 3 and the anode humidifier 7, and it becomes liquefied easily. As a result, it becomes easy to humidify the solid polyelectrolyte membrane 51 of the fuel cell 1.

[0051]Since heat exchange is performed while the cooling liquid outlet temperature T2 is controlled in the range in which the cooling fluid inlet temperature T1 does not exceed upper limit temperature by slight height and hydrogen gas and air, and cooling fluid flow into a uniform direction within the fuel cell 1 further, Temperature in fuel cell 1 exit of hydrogen off-gas and air off-gas can be made high. As a result, the dew point of these off-gas can be made high, and the moisture content which exists by the gaseous phase (steam) in off-gas can be increased. Therefore, the eccritic nature of the moisture in the fuel cell 1 improves, and a water blockade becomes difficult to take place in the hydrogen gas passage 56 and the air duct 57.

[0052]Since the cooling liquid outlet temperature T2 is controlled more highly, the circulating load of cooling fluid can be decreased and the power consumption of the water pump 15 can be decreased.

[0053][A 4th embodiment] Next, a 4th embodiment of the cooling system of the fuel cell concerning this invention is described with reference to the Drawings of drawing 9 and drawing 10. Although the target temperature gradient (desired value) of temperature-gradient deltaT of the cooling liquid outlet temperature T2 and the cooling fluid inlet temperature T1 is made regularity (for example, 10deg) in the cooling system of each embodiment mentioned above, The target temperature gradient of temperature-gradient deltaT is made variable, and it is made to change a target temperature gradient in the cooling system of a 4th embodiment according to the output (production of electricity) of the fuel cell 1.

[0054]The Reason for making introduction and a target temperature gradient variable is

explained. The calorific value of the fuel cell 1 differs according to the output (power generation current) of the fuel cell 1, their calorific value is small in a low-power output (power generation current is small) field, and calorific value is large in a high-output (power generation current is large) field. Therefore, there are few flows of the cooling fluid which cools the fuel cell 1, and they can be managed with a low-power output field, and many flows of cooling fluid are needed in a high-output field.
[0055]If the flow of cooling fluid decreases in a low-power output field, here with the relation of the cell position in dispersion and the fuel cell 1 of the cooling fluid passage structure in the fuel cell 1. Reservation of a uniform cooling state becomes difficult to all the cells, temperature dispersion between cells or to a cell position occurs, a high temperature region (heat point) produces selectively, and there is a possibility of hurting one's solid polyelectrolyte membrane 51. Therefore, in the low-power output field of the fuel cell 1, the direction to which set small temperature-gradient deltaT of the cooling liquid outlet temperature T2 and the cooling fluid inlet temperature T1, and the cooling fluid flow was made to increase becomes difficult to produce a heat point, and is preferred for the fuel cell 1.
[0056]On the other hand, if the flow of cooling fluid increases in a high-output field, even if there is dispersion in the cooling fluid passage structure in the fuel cell 1, since an almost uniform cooling state is securable in each cell, a heat point will not occur. However, if it is going to secure temperature-gradient deltaT of the cooling liquid outlet temperature T2 and the cooling fluid inlet temperature T1 to the same temperature-gradient deltaT as the time of low and the Tsuyoshi Nakade field of the fuel cell 1, Since a cooling fluid flow becomes large, the output of the water pump 15 will become large, and the power consumption of the water pump 15 will become large. Here, generation efficiency will fall as a result from the electric power of the water pump 15 being provided by power generation of the fuel cell 1. Therefore, in the high-output field of the fuel cell 1, the direction which set up greatly temperature-gradient deltaT of the cooling liquid outlet temperature T2 and the cooling fluid inlet temperature T1, and decreased the cooling fluid flow can decrease the power consumption of the water pump 15, and is preferred on energy management. So, in the cooling system of this 4th embodiment, the target temperature gradient was changed according to the output of the fuel cell 1, and it decided to perform temperature control of cooling fluid.
[0057]Next, the cooling system of a 4th embodiment is explained concretely. In the following explanation, the explanation is omitted about the composition of a cooling system as the same as what is shown in drawing 1. Drawing 9 sets upper limit temperature of cooling fluid inlet temperature to 80 degreeC, shows the temperature control flow chart of the cooling fluid in the case of making a target temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature into the target temperature gradient deltaTalpha according to the output of the fuel cell 1, and explains temperature control processing according to this.
[0058]First, in order to know the output (production of electricity) of the fuel cell 1, the power generation current of the fuel cell 1 detected with the power-generation-current metering device 18 is read (Step S301). Next, the target temperature gradient deltaTalpha with the cooling liquid outlet temperature T2 and the cooling fluid inlet temperature T1 is computed according to the power generation current of the fuel cell 1 (Step S302). The target temperature gradient deltaTalpha may be computed with reference to a target temperature-gradient map as shown, for example in drawing 10, or may be computed by calculation based on the expression of relations of power generation current and the target temperature gradient deltaTalpha.
[0059]If the target temperature-gradient map of drawing 10 is explained, in one or less IA, the target temperature gradient deltaTalpha has constant power generation current here at deltaT1, Power generation current becomes gradually large [the target temperature gradient deltaTalpha] from deltaT1 to deltaT2 by two or less IA exceeding IA1, Power generation current becomes gradually large [the target temperature gradient deltaTalpha] from deltaT2 to deltaT3 by less than three IA exceeding IA2, and power generation current is constant [the target temperature gradient deltaTalpha] in three or more IA(s) at deltaT3. The increasing rate of the target temperature gradient [in / in power generation current / IA1-IA2] deltaTalpha is set up more greatly than the increasing rate of the target temperature gradient [in / in power

generation current / IA2-IA3] deltaTalpha.
[0060]Thus, after computing the target temperature gradient deltaTalpha according to the power generation current of the fuel cell 1, The cooling fluid inlet temperature T1 and the cooling liquid outlet temperature T2 which were detected with the inlet temperature sensor 16 and the outlet temperature sensor 17 are read (Step S303), and it is judged whether the cooling fluid inlet temperature T1 is lower than upper limit temperature (80degreeC) (Step S304). When a decision result is "NO" (the cooling fluid inlet temperature T1. more than 80 degreeC), the output of the water pump 15 is increased (Step S305), and execution of this routine is once ended. By this, the circulating load of cooling fluid will increase and the cooling fluid inlet temperature T1 will be controlled in the direction to lower.
[0061]When the decision result in Step S304 is "YES" (the cooling fluid inlet temperature T1. less than 80 degreeC), Temperature-gradient deltaT of the cooling liquid outlet temperature T2 and the cooling fluid inlet temperature T1 is computed (Step S306), and it is judged whether computed temperature-gradient deltaT is smaller than the target temperature gradient deltaTalpha (Step S307). When a decision result is "NO" (temperature-gradient deltaT beyond the target temperature gradient deltaTalpha), the output of the water pump 15 is increased (Step S305), and execution of this routine is once ended. By this, the circulating load of cooling fluid will increase and temperature-gradient deltaT will be controlled in the direction which becomes small.
[0062]When the decision result in Step S307 is "YES" (temperature-gradient deltaT less than the target temperature gradient deltaTalpha), the output of the water pump 15 is reduced (Step S308), and execution of this routine is once ended. By this, the circulating load of cooling fluid will decrease and temperature-gradient deltaT will be controlled in the direction which becomes large. By performing the above temperature control processing, it comes to converge below on 80 degreeC, and temperature-gradient deltaT comes to converge the cooling fluid inlet temperature T1 on the target temperature gradient deltaTalpha according to the output of the fuel cell 1.
[0063]Therefore, when the output of the fuel cell 1 is low. Temperature-gradient deltaT of the cooling liquid outlet temperature T2 and the cooling fluid inlet temperature T1 comes to be controlled by the small temperature gradient, as a result, the cooling fluid flow which flows into the fuel cell 1 can be boiled comparatively, and can be enlarged now, a heat point can be made hard to produce and damage to the fuel cell 1 can be prevented. On the other hand, when the output of the fuel cell 1 is high, temperature-gradient deltaT of the cooling liquid outlet temperature T2 and the cooling fluid inlet temperature T1 comes to be controlled by the large temperature gradient, as a result, the cooling fluid flow which flows into the fuel cell 1 can be boiled comparatively, can be made small now, the power consumption of the water pump 15 can be decreased, and the generation efficiency of the fuel cell 1 improves.
[0064]Also in the cooling system of this 4th embodiment, there is the same operation as a 1st embodiment, therefore improvement in the humidification nature to the fuel cell 1, improvement in moisture eccritic nature in the fuel cell 1, and reduction of the power consumption of the water pump 15 can be realized. The temperature control of the cooling fluid which changes and performs a target temperature gradient according to the output of the fuel cell 1 as mentioned above is applicable also to the cooling system of composition of being shown in drawing 6 or drawing 8.
[0065]
[Effect of the Invention]According to the invention indicated to Claim 1, fuel cell outlet temperature of off-gas can be made high so that it may explain above, As a result, since the dew point of off-gas can be made high, the moisture content which exists by the gaseous phase (steam) in off-gas is increased and this can be discharged from a fuel cell with off-gas, the outstanding effect that the eccritic nature of the moisture in a fuel cell improves is done so. According to the invention indicated to Claim 1, since it comes to control cooling liquid outlet temperature more highly and the circulating load of cooling fluid can be decreased, it is effective in the ability to decrease the power consumption of a circulating pump.
[0066]According to the invention indicated to Claim 2, fuel cell outlet temperature of off-gas can

be made high, As a result, since the dew point of off-gas can be made high, the moisture content which exists by the gaseous phase (steam) in off-gas is increased and this can be discharged from a fuel cell with off-gas, the outstanding effect that the eccritic nature of the moisture in a fuel cell improves is done so.

[0067]Since the heating method is heating the humidifier with cooling fluid according to the invention indicated to Claim 2, Rise the temperature of the reactant gas supplied to a fuel cell, and the humidification to the reactant gas in a humidifier is promoted, And since it is cooled with cooling fluid immediately after supplying a fuel cell, and the steam in reactant gas solidifies the reactant gas heated and humidified, it becomes liquefied easily and it becomes easy to humidify a fuel cell, the outstanding effect that the humidification nature to a fuel cell improves is done so.

[0068]According to the invention indicated to Claim 2, since it comes to control cooling liquid outlet temperature more highly and the circulating load of cooling fluid can be decreased, it is effective in the ability to decrease the power consumption of a circulating pump.

[0069]When a fuel cell is low-power output according to the invention indicated to Claim 3, Since the cooling fluid flow which sets up small a temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature, and flows through a fuel cell can be made to increase, Can make a heat point hard to produce in a fuel cell, can prevent damage to a fuel cell, and on the other hand, when a fuel cell is high power, Since the cooling fluid flow which sets up greatly a temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature, and flows through a fuel cell can be decreased, the power consumption of a circulating pump can be decreased and the outstanding effect that the generation efficiency of a fuel cell improves is done so.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention]This invention relates to the cooling system of a fuel cell.
In particular, it is related with the cooling system of liquid cooling.

[Translation done.]

PRIOR ART

[Description of the Prior Art]In the fuel cell carried in a fuel cell electric vehicle etc. For example, it consists of a stack constituted by carrying out the plural laminates of the cell which put the solid polyelectrolyte membrane which consists of a solid polymer ion-exchange membrane etc. from both sides with the anode and the cathode, and was formed, Some are provided with the hydrogen gas passage to which hydrogen gas is supplied as fuel gas, the air duct to which the air which contains oxygen as oxidant gas is supplied, and the coolant path to which cooling fluid is supplied. Hereafter, fuel gas and oxidant gas are named generically and it is called reactant gas. In this fuel cell, solid polyelectrolyte membrane is passed, even a cathode moves, the hydrogen ion generated by catalytic reaction in the anode causes and generates oxygen and electrochemical reaction with a cathode, and water is generated in that case.
[0003]By the way, since there is an operating temperature range in a fuel cell, it is necessary to cool, although generation of heat is followed on power generation of a fuel cell so that a fuel cell may not carry out temperature up more than upper limit temperature. Therefore, the cooling system which pours a refrigerant, takes heat and cools a fuel cell is formed in said coolant path of the fuel cell. There is a thing it was made to circulate the cooling fluid as a refrigerant between a fuel cell and a radiator (radiator) with a circulating pump in the cooling system of this fuel cell as indicated by JP,H10-340734,A. In this cooling system, when the cooling fluid which took heat from the fuel cell and was heated flows through a radiator, heat was radiated in the open air in the heat of cooling fluid, and cooling fluid is cooled.
[0004]The circulating load of cooling fluid was controlled so that it was made desirable to cool so that the internal temperature of a fuel cell may become uniform, therefore it decreased a temperature gradient with the cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature as much as possible on a system conventionally, as indicated by said gazette.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention]According to the invention indicated to Claim 1, fuel cell outlet temperature of off-gas can be made high so that it may explain above, As a result, since the dew point of off-gas can be made high, the moisture content which exists by the gaseous phase (steam) in off-gas is increased and this can be discharged from a fuel cell with off-gas, the outstanding effect that the eccritic nature of the moisture in a fuel cell improves is done so. According to the invention indicated to Claim 1, since it comes to control cooling liquid outlet temperature more highly and the circulating load of cooling fluid can be decreased, it is effective in the ability to decrease the power consumption of a circulating pump.
[0066]According to the invention indicated to Claim 2, fuel cell outlet temperature of off-gas can be made high, As a result, since the dew point of off-gas can be made high, the moisture content which exists by the gaseous phase (steam) in off-gas is increased and this can be discharged from a fuel cell with off-gas, the outstanding effect that the eccritic nature of the moisture in a fuel cell improves is done so.
[0067]Since the heating method is heating the humidifier with cooling fluid according to the invention indicated to Claim 2, Rise the temperature of the reactant gas supplied to a fuel cell, and the humidification to the reactant gas in a humidifier is promoted, And since it is cooled with cooling fluid immediately after supplying a fuel cell, and the steam in reactant gas solidifies the reactant gas heated and humidified, it becomes liquefied easily and it becomes easy to humidify a fuel cell, the outstanding effect that the humidification nature to a fuel cell improves is done so.
[0068]According to the invention indicated to Claim 2, since it comes to control cooling liquid outlet temperature more highly and the circulating load of cooling fluid can be decreased, it is effective in the ability to decrease the power consumption of a circulating pump.
[0069]When a fuel cell is low-power output according to the invention indicated to Claim 3, Since the cooling fluid flow which sets up small a temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature, and flows through a fuel cell can be made to increase, Can make a heat point hard to produce in a fuel cell, can prevent damage to a fuel cell, and on the other hand, when a fuel cell is high power, Since the cooling fluid flow which sets up greatly a temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature, and flows through a fuel cell can be decreased, the power consumption of a circulating pump can be decreased and the outstanding effect that the generation efficiency of a fuel cell improves is done so.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]However, lessening a temperature gradient with the cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature in this way, Since it is carrying out in the direction which lowers cooling liquid outlet temperature, therefore the circulating load of cooling fluid will be increased and the power consumption of the circulating pump increased, it was disadvantageous on energy management.
[0006]As mentioned above, although water is generated when generating electricity, this water has some which exist by the gaseous phase as a steam in unreacted reactant gas, i.e., off-gas, and a fuel cell has some which serve as a fluid, dissociate from off-gas, and exist by the liquid phase. Since the moisture which exists in off-gas as a steam is discharged from a fuel cell with off-gas, it does not become a problem, but a liquefied thing has a possibility of blocking a part of reactant gas way depending on the case, and a desirable gestalt cannot be said. Then, considering the viewpoint of discharge of the moisture of produced water etc., since the moisture content which the one where the internal temperature of a fuel cell is higher can get the dew point, can make contain many moisture in off-gas by the gaseous phase (steam), and can discharge with off-gas can be increased, it is desirable. However, since it was controlling in the direction which lessens a temperature gradient with the cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature, and lowers cooling liquid outlet temperature as conventionally mentioned above, the moisture in off-gas became the liquid phase easily, and there was room of improvement in respect of the eccritic nature of moisture.
[0007]On the other hand, in the fuel cell using solid polyelectrolyte membrane. In order to secure the ion conductivity of solid polyelectrolyte membrane to a predetermined state and to maintain a good power generation state, The reactant gas (hydrogen gas and air) supplied to a fuel cell is humidified with the humidifier, and when this humidified reactant gas condenses within a fuel cell and adheres to solid polyelectrolyte membrane, the ion conductivity of solid polyelectrolyte membrane is raised. Thus, considering the viewpoint of the humidification to a fuel cell, it will be easy to solidify the steam in reactant gas, and the one where the internal temperature of a fuel cell is lower will be preferred. It was very difficult to reconcile the humidification nature to a fuel cell, and the eccritic nature of the moisture mentioned above, and to control the internal temperature of a fuel cell from such a situation.
[0008]Then, this invention provides the cooling system of the fuel cell excellent in the eccritic nature of the moisture in a fuel cell by securing a temperature gradient positively to the internal temperature distribution in the fuel cell of the structure where the flow direction of cooling fluid was made reactant gas in the abbreviated uniform direction. This invention by securing a temperature gradient positively to the internal temperature distribution in the fuel cell of the structure where the flow direction of cooling fluid was made reactant gas in the abbreviated uniform direction, The cooling system of the fuel cell which can aim at coexistence of improvement in the wastewater nature of the moisture in a fuel cell and improvement in the humidification nature to solid polyelectrolyte membrane is provided.

[Translation done.]

MEANS

[Means for Solving the Problem]In order to solve an aforementioned problem, an invention indicated to Claim 1, A fuel cell (for example, fuel cell 1 in each embodiment mentioned later) which generates electricity by making into reactant gas fuel gas (for example, hydrogen gas in each embodiment mentioned later), and oxidant gas (for example, air in each embodiment mentioned later), Cooling fluid with a circulating pump (for example, water pump 15 in each embodiment mentioned later) Said fuel cell and a radiator. It is made to circulate between (for example, the radiators 11 in each embodiment mentioned later), A cooling method (for example, coolant circuits 12 in each embodiment mentioned later) which pours cooling fluid to said reactant gas and an abbreviated uniform direction within said fuel cell, cools this fuel cell, and radiates heat outside in heat from cooling fluid with said radiator, A control means which controls said circulating pump so that a predetermined temperature gradient is secured between cooling liquid outlet temperature of said fuel cell, and cooling fluid inlet temperature. for example, the step S103,105,106 in a 1st embodiment mentioned later -- and, It is a cooling system of a fuel cell provided with Step S208,209,210 in a 2nd embodiment, and Step S305,307,308 in a 4th embodiment.
[0010]By constituting in this way, by control of a circulating pump by said control means. Since a predetermined temperature gradient is secured between cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature, Cooling liquid outlet temperature will be controlled by slight height, and further from reactant gas and cooling fluid flowing into an abbreviated uniform direction within a fuel cell. Fuel cell outlet temperature of unreacted reactant gas (henceforth off-gas) can be made high, as a result, the dew point of off-gas can be made high, and it becomes possible to increase a moisture content which exists by the gaseous phase (steam) in off-gas. Since it comes to control cooling liquid outlet temperature more highly, a circulating load of cooling fluid can be decreased.
[0011]An invention indicated to Claim 2 Fuel gas (for example, hydrogen gas in each embodiment mentioned later), and oxidant gas. A fuel cell (for example, fuel cell 1 in each embodiment mentioned later) which generates electricity by making (for example, air in each embodiment mentioned later) into reactant gas, A humidifier (for example, the cathode humidifier 3 and the anode humidifier 7 in each embodiment mentioned later) which humidifies said reactant gas supplied to said fuel cell, Cooling fluid with a circulating pump (for example, water pump 15 in each embodiment mentioned later) Said fuel cell and a radiator. It is made to circulate between (for example, the radiators 11 in each embodiment mentioned later), A cooling method (for example, coolant circuits 12 in each embodiment mentioned later) which pours cooling fluid to said reactant gas and an abbreviated uniform direction within said fuel cell, cools this fuel cell, and radiates heat outside in heat from cooling fluid with said radiator, A heating method (for example, water jackets [in / the 2nd room / 3d, 7d and a 3rd embodiment] 3e and 7e in a 1st and 2nd embodiment mentioned later) which heats said humidifier with said cooling fluid discharged from said fuel cell, A control means which controls said circulating pump so that a predetermined temperature gradient is secured between cooling liquid outlet temperature of said fuel cell, and cooling fluid inlet temperature. for example, the step S103,105,106 in a 1st embodiment mentioned later -- and, It is a cooling system of a fuel cell provided with Step

S208,209,210 in a 2nd embodiment, and Step S305,307,308 in a 4th embodiment.
[0012]By constituting in this way, by control of a circulating pump by said control means. Since a predetermined temperature gradient is secured between cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature, Cooling liquid outlet temperature will be controlled by slight height, and further from reactant gas and cooling fluid flowing into an abbreviated uniform direction within a fuel cell. Fuel cell outlet temperature of off-gas can be made high, as a result, the dew point of off-gas can be made high, and it becomes possible to increase a moisture content which exists by the gaseous phase (steam) in off-gas.
[0013]Since a heating method is heating a humidifier with cooling fluid, temperature of reactant gas supplied to a fuel cell is risen, and humidification to reactant gas in a humidifier is promoted. And a predetermined temperature gradient is secured between cooling liquid outlet temperature of a fuel cell, and cooling fluid inlet temperature, Within a fuel cell, since reactant gas and cooling fluid flow into an abbreviated uniform direction, it is cooled with cooling fluid immediately after supplying a fuel cell, and a steam in reactant gas solidifies reactant gas heated and humidified with said humidifier, it becomes liquefied easily, and becomes easy to humidify a fuel cell. Since it comes to control cooling liquid outlet temperature more highly, a circulating load of cooling fluid can be decreased.
[0014]An invention indicated to Claim 3 changes a desired value of said temperature gradient in the invention according to claim 1 or 2 according to an output of said fuel cell. When a fuel cell is low-power output by constituting in this way, Set up small a temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature, and it becomes possible to make a cooling fluid flow which flows through a fuel cell increase, and on the other hand, when a fuel cell is high power, It becomes possible to set up greatly a temperature gradient with cooling liquid outlet temperature and cooling fluid inlet temperature, and to decrease a cooling fluid flow which flows through a fuel cell.
[0015]
[Embodiment of the Invention]Hereafter, the embodiment of the cooling system (it may only be called a cooling system) of the fuel cell concerning this invention is described with reference to the Drawings of drawing 10 from drawing 1. The embodiment described below is the mode applied to the cooling system of the fuel cell carried in a fuel cell electric vehicle.
[0016][A 1st embodiment] A 1st embodiment of the cooling system of the fuel cell concerning this invention is described with reference to the Drawings of drawing 5 from drawing 1. Drawing 1 is an outline lineblock diagram of a cooling system. The fuel cell 1 used as introduction and a cooling object is explained. As the fuel cell 1 is a solid polyelectrolyte membrane type fuel cell and it is shown in drawing 2, For example, the solid polyelectrolyte membrane 51 which consists of a solid polymer ion-exchange membrane etc. is put from both sides with the anode 52 and the cathode 53, The hydrogen gas passage 56 which it becomes from the stack constituted by carrying out the plural laminates of the cell 55 which furthermore pinched the outside with the separators 54 and 54 of the couple, and was formed and to which hydrogen gas is supplied as fuel gas, It has the air duct 57 to which the air which contains oxygen as oxidant gas is supplied, and the coolant path 58 to which cooling fluid is supplied. And the solid polyelectrolyte membrane 51 is passed, even the cathode 53 moves, the hydrogen ion generated by catalytic reaction in the anode 52 causes and generates oxygen and electrochemical reaction with the cathode 53, and water is generated in that case. With the cooling fluid which flows through said coolant path 58, heat is taken and it cools so that the fuel cell 1 may not exceed upper limit temperature by generation of heat accompanying this power generation.
[0017]In this fuel cell 1, the hydrogen gas passage 56, the air duct 57, and the coolant path 58 are mutually parallel, and are provided. Drawing 3 is a perspective view showing these passages 56, 57, and 58 typically, and these passages 56, 57, and 58 are moved in a zigzag direction and established in the same gestalt by each from the entrance of the upper left part of the cell 55 to the exit of a lower right part. Therefore, in this embodiment, the hydrogen gas passage 56, the air duct 57, and the coolant path 58 cover that overall length, and the flow direction of each fluid is made into the uniform direction.
[0018]Next, a cooling system is explained in accordance with the flow of each fluid. After having

been pressurized by the air compressor 2, being humidified with the cathode humidifier 3, supplying the air duct 57 of the fuel cell 1 and presenting power generation with oxygen in this air as an oxidizer, the open air is discharged as air off-gas from the fuel cell 1, and is emitted to the atmosphere via the pressure control valve 4. Revolving speed control of the air compressor 2 is carried out so that the air of the mass according to the output demanded of the fuel cell 1 may be supplied to the fuel cell 1, and opening control of the pressure control valve 4 is carried out so that the air supply pressure to the fuel cell 1 may serve as a pressure value according to the operational status of the fuel cell 1.

[0019]As for the cathode humidifier 3, the inside of the casing 3a is isolated by two upper and lower sides with the water-vapor-permeation film 3b, The upper cooling fluid discharged from the fuel cell 1 so that the 1st room of air duct 57 entrance of the air compressor 2 and the fuel cell 1 might be connected to 3c and it might mention later to lower 3d of room [2nd] circulates. The water-vapor-permeation film 3b has the function to make only a steam penetrate bordering on this water-vapor-permeation film 3b to the one where water vapor pressure is lower from the one where water vapor pressure is higher.

[0020]After the hydrogen gas emitted from the high pressure hydrogen tank which is not illustrated on the other hand is decompressed by the fuel supply control valve 5, it passes along the ejector 6, is humidified with the anode humidifier 7, and is supplied to the hydrogen gas passage 56 of the fuel cell 1. After power generation is presented with this hydrogen gas, unreacted hydrogen gas is discharged as hydrogen off-gas from the fuel cell 1, is attracted by the ejector 6 through the hydrogen off-gas recovery passage 8, joins the hydrogen gas supplied from said high pressure hydrogen tank, and is again supplied to the fuel cell 1.

[0021]The fuel supply control valve 5 consists of a proportional pressure control valve of an air type, for example, and is inputted via the pneumatic-signal introducing path 9 by making into signal pressure the pressure of the air supplied from the air compressor 2, and pressure reduction control is carried out so that the pressure of hydrogen gas of fuel supply control valve 5 exit may serve as a specified pressure range according to said signal pressure. The hydrogen off-gas recovery passage 8 is provided with the purge valve 10, and when a predetermined condition is fulfilled, valve-opening control is carried out, and it drains the purge valve 10 to the exterior so that the hydrogen gas passage 56 of the fuel cell 1 may not be covered with water.

[0022]The anode humidifier 7 is making the same structure as the cathode humidifier 3, the inside of the casing 7a is isolated by two upper and lower sides with the water-vapor-permeation film 7b -- the upper 1st -- room 7c -- the ejector 6 -- and -- and hydrogen gas passage 56 entrance of the fuel cell 1 is connected, and the cooling fluid discharged from the fuel cell 1 so that it might mention later circulates to lower 7d of room [2nd]. Here, said cathode humidifier 3 humidifies air with the steam of the cooling fluid which penetrated the water-vapor-permeation film 3b, supplies the humidified air to the fuel cell 1, and the anode humidifier 7 humidifies hydrogen gas with the steam of the cooling fluid which penetrated the water-vapor-permeation film 7b, and it supplies the humidified hydrogen gas to the fuel cell 1. Thereby, the ion conductivity of the solid polyelectrolyte membrane of the fuel cell 1 is secured to a predetermined state.

[0023]The cooling fluid for cooling the fuel cell 1, Pressure up is carried out by the water pump (WP) 15 which is a circulating pump, and the radiator (radiator) 11 is supplied, Cooling fluid is cooled by radiating heat outside in the radiator 11, Then, the fuel cell 1 is supplied, when it passes along the coolant path 58 in the fuel cell 1, heat is taken from the fuel cell 1, the fuel cell 1 is cooled, and via the water pump 15, again, the cooling fluid heated by this returns to the radiator 11, and is cooled. Namely, coolant circuits where cooling fluid connects the fuel cell 1, the water pump 15, and the radiator 11 to a closed circuit

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[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is an outline lineblock diagram of a 1st embodiment in the cooling system of the fuel cell concerning this invention.
[Drawing 2]It is an outline sectional view of the fuel cell in a 1st embodiment.
[Drawing 3]It is a mimetic diagram of the reactant gas passage of the fuel cell in a 1st embodiment, and a coolant path.
[Drawing 4]It is a temperature control flow chart of the cooling fluid in a 1st embodiment.
[Drawing 5]It is a mimetic diagram showing other examples of the reactant gas passage of a fuel cell, and a coolant path.
[Drawing 6]It is an outline lineblock diagram of a 2nd embodiment in the cooling system of the fuel cell concerning this invention.
[Drawing 7]It is a temperature control flow chart of the cooling fluid in a 1st embodiment.
[Drawing 8]It is an outline lineblock diagram of a 3rd embodiment in the cooling system of the fuel cell concerning this invention.
[Drawing 9]It is a coolant temperature control flow chart of a 4th embodiment in the cooling system of the fuel cell concerning this invention.
[Drawing 10]It is an example of the target temperature-gradient map in a 4th embodiment.
[Description of Notations]
1 Fuel cell
3 Cathode humidifier
3d and 7d The 2nd room (heating method)
3e and 7e Water jacket (heating method)
7 Anode humidifier
11 Radiator (radiator)
12 Coolant circuits (cooling method)
15 Water pump (circulating pump)
58 Coolant path (cooling method)
Step S103,105,106 Control means
Step S208,209,210 Control means

[Translation done.]

* NOTICES *

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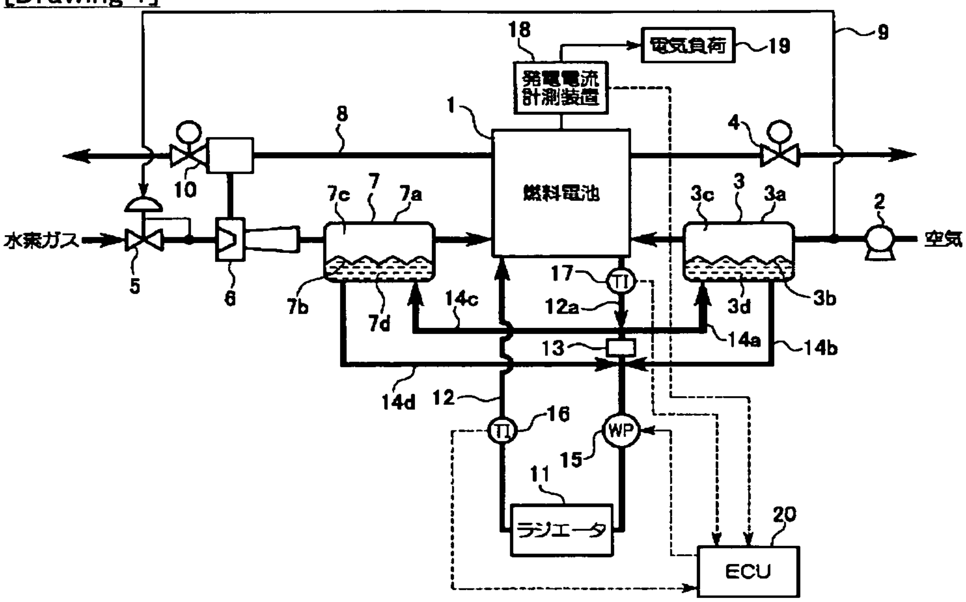
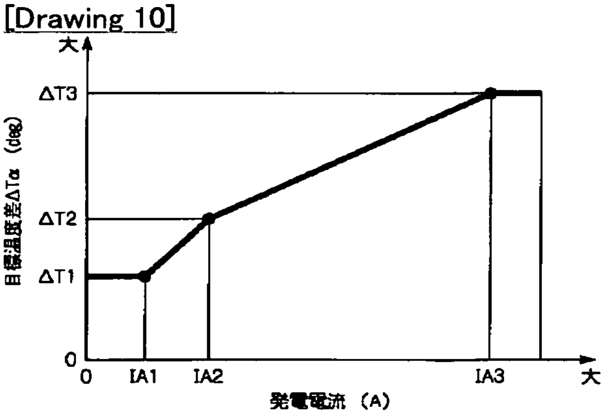
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

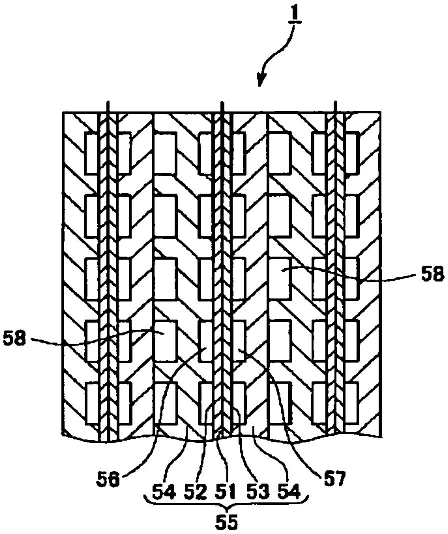
[Drawing 1]



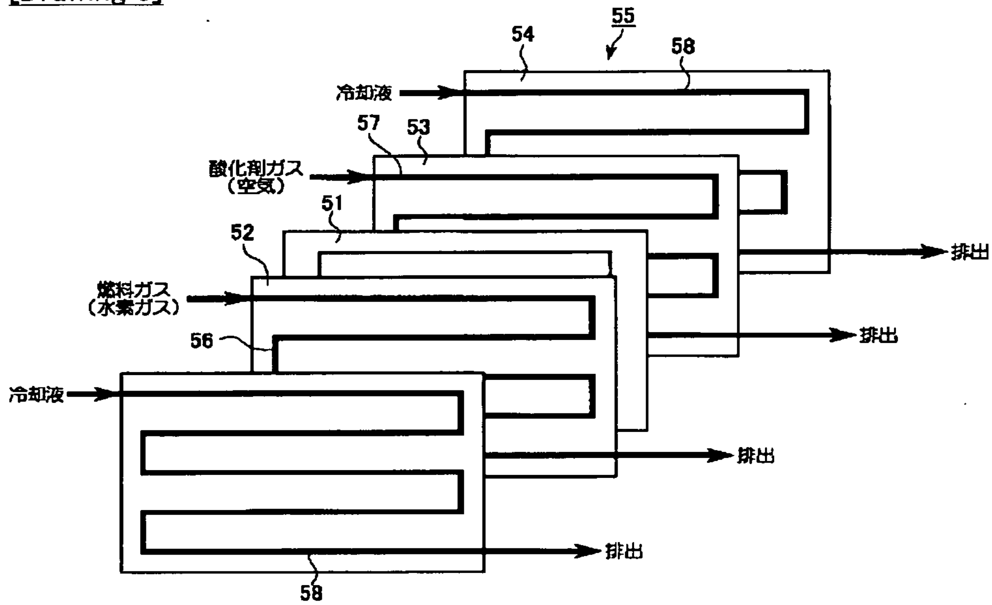
[Drawing 10]



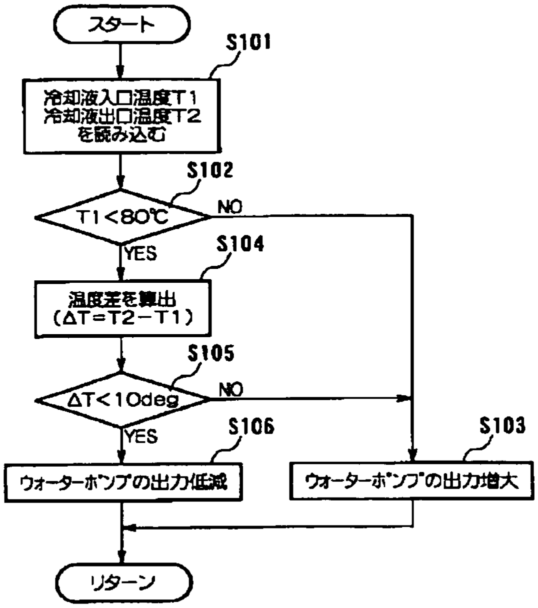
[Drawing 2]



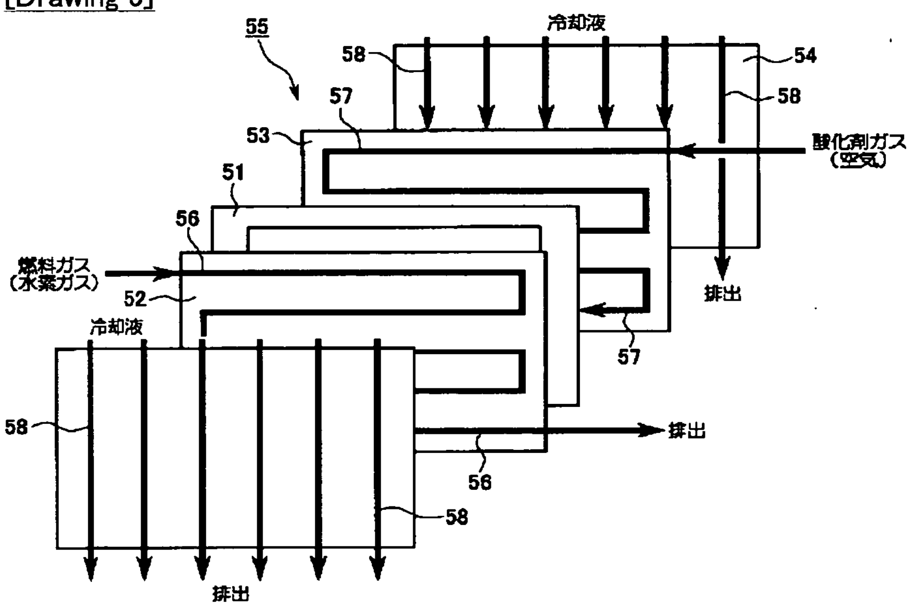
[Drawing 3]



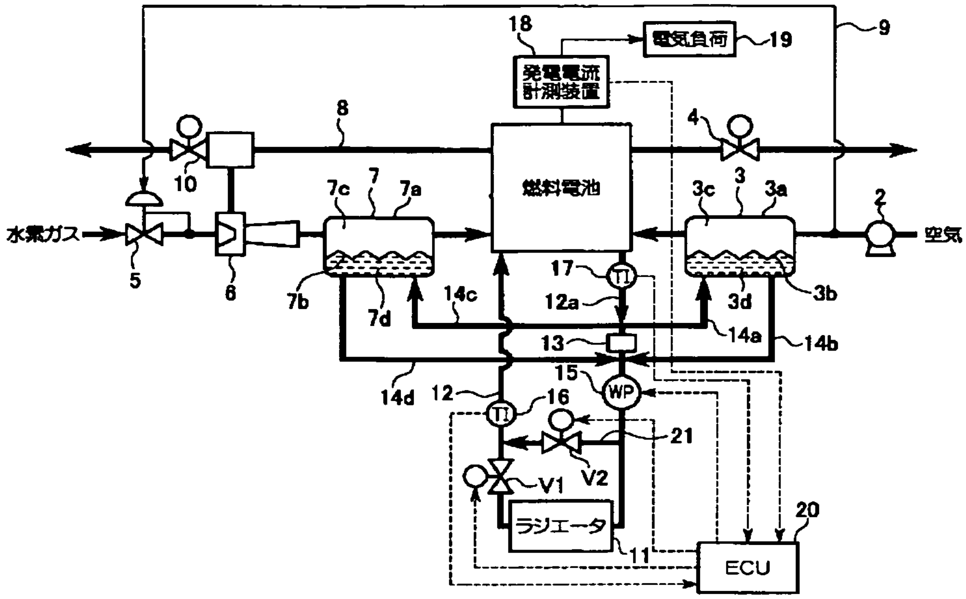
[Drawing 4]



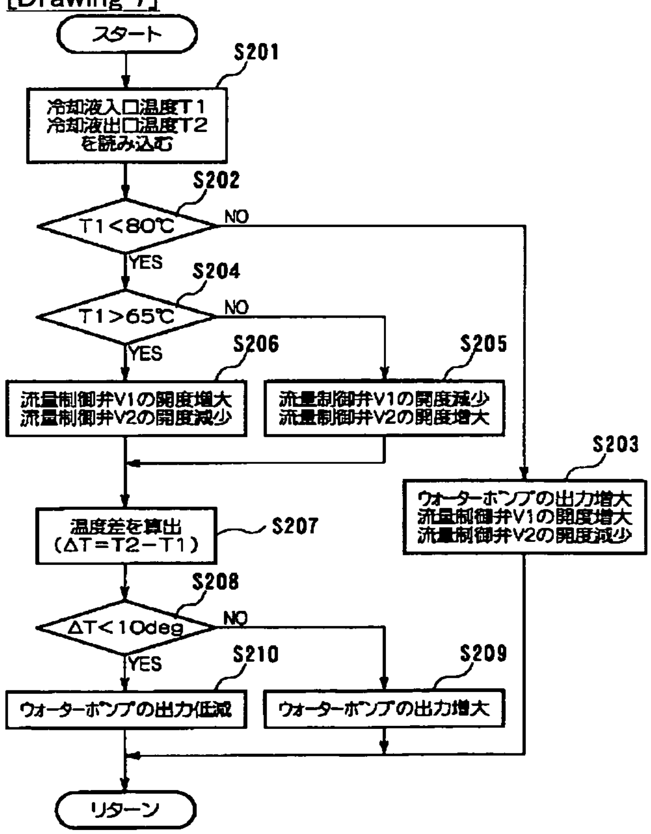
[Drawing 5]



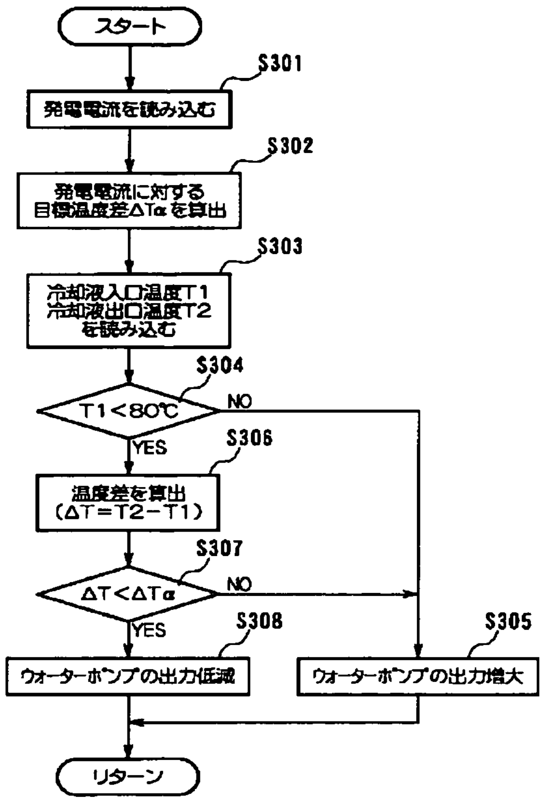
[Drawing 6]



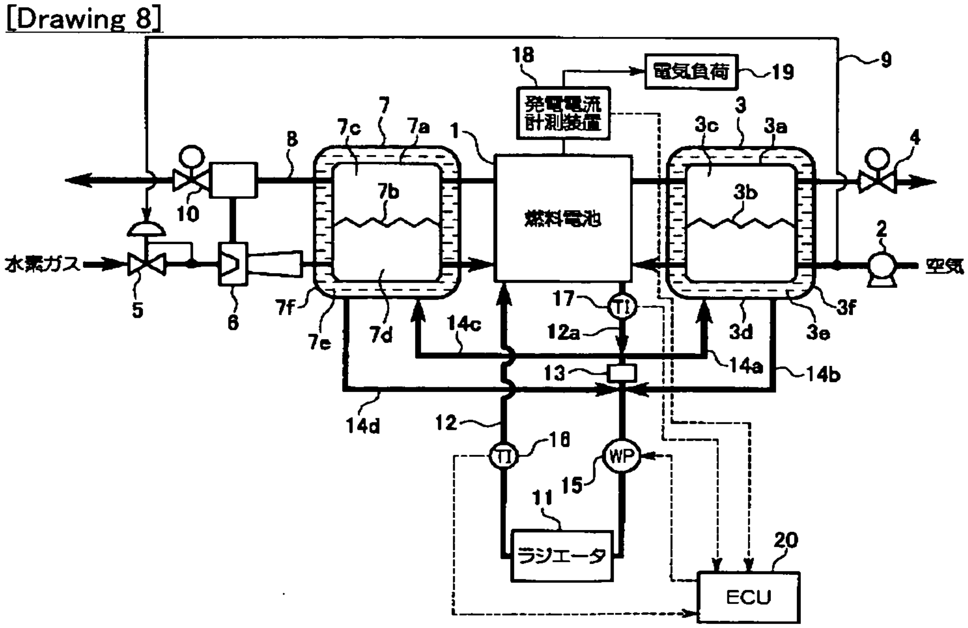
[Drawing 7]



[Drawing 9]



[Drawing 8]



[Translation done.]